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ORI

AVIATION AND PROGRAMMATIC ANALYSES

28 MARCH 1977

VOLUME III

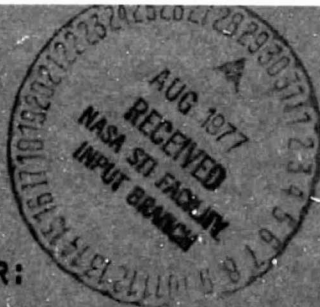
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PREPARED FOR:

THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771

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AVIATION AND PROGRAMMATIC ANALYSES

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FOREWORD

This is Volume III of a three volume final report which consolidates the studies and analyses conducted by Operations Research, Inc. (ORI) for the National Aeronautics and Space Administration, Goddard Space Flight Center, under Contract No. NAS5-23477.

This volume contains documents generated under Task III - Development of Special Issue Papers.

MULTILATERAL AERONAUTICAL DEVELOPMENTS

STATUS REPORT/BRIEFING	APRIL 27, 1976
SELECTED SUMMARY TABULATIONS AND ARTICLES	APRIL 27, 1976
POSITION PAPER (DRAFT)	JUNE 1, 1976

Prepared by:
Operations Research, Inc.

MULTILATERAL
AERONAUTICAL DEVELOPMENTS

STATUS REPORT/BRIEFING
27 APRIL 1976

MULTILATERAL AERONAUTICAL DEVELOPMENTS

KEY QUESTIONS

- ARE WE TRANSFERRING IMPORTANT AERONAUTICS R&T OVERSEAS SUCH THAT THIS TRANSFER REPRESENTS A NET DISBENEFIT TO THE U.S.?
- WHAT IS BEING TRANSFERRED? UNDER WHAT TYPES OF ARRANGEMENTS?
- WHAT LED US TO OUR CURRENT POSITION? WHAT ARE THE TRENDS?
- WHAT ARE THE ESSENTIAL PROS AND CONS?
- WHAT STUDIES HAVE BEEN DONE IN THIS AREA AND WHAT ARE THEIR RESULTS?
- WHAT CONCLUSIONS CAN BE DRAWN AT THIS TIME?
- WHAT RECOMMENDATIONS CAN BE MADE AT THIS TIME?

MULTILATERAL AERONAUTICAL DEVELOPMENTS

OBJECTIVE

A PRELIMINARY ASSESSMENT OF:

- TRENDS LEADING TO THESE DEVELOPMENTS
- THE NATURE OF THESE DEVELOPMENTS
- RELATIONSHIPS BETWEEN DEVELOPMENTS AND R&T
- THE RESULTS OF PREVIOUS ANALYSES
- CONCLUSIONS THAT CAN BE DRAWN
- IMPLICATIONS FOR U.S. AERONAUTICAL R&T POLICY

HISTORICAL TRENDS

AFTER W.W.II

- U.S. AVIATION DOMINANCE
- MILITARY-CIVIL INTERACTIONS
- STRENGTHS OF AIRFRAME INDUSTRY
 - EFFICIENCY, FINANCING
- GENERAL ECONOMIC GROWTH AND ROLE OF AERONAUTICS

PAST 5-10 YEARS

- INCREASING FINANCIAL REQUIREMENTS AND RISK
- REDUCTION IN MILITARY-CIVIL INTERACTIONS
- ENERGY PROBLEM
- INCREASED FOREIGN COMPETITION AND SUBSIDY
- GENERAL ECONOMIC SLOWDOWN

NATURE OF MULTILATERAL AERONAUTICAL DEVELOPMENTS

- SUBCONTRACTS (E.G., BUILD PARTS OF AIRCRAFT)
 - PRODUCTION LICENSING (E.G., PRODUCTION OVERSEAS)
 - JOINT DEVELOPMENT (E.G., CONCORDE)
 - DIRECT INVESTMENT IN FOREIGN COUNTRIES
 - DIRECT SALE OF TECHNOLOGY (E.G., PATENTS)
-

NSF STUDIES

- EXPORTS OF PRODUCTS
- LICENSING OF TECHNOLOGY
- FOREIGN DIRECT INVESTMENT

THE NEXT COMMERCIAL JET 1/

- FUEL AND OPERATING ECONOMY; LOW NOISE
- 200 SEAT, SHORT-TO-MEDIUM RUNS
- NEEDED IN 4-5 YEARS (START REPLACING 707's, DC-8's AND 727's)
- U.S. MANUFACTURERS CANNOT GET ADVANCE ORDERS FROM U.S. AIRLINES
- ALL MANUFACTURERS SEEKING DEVELOPMENT AND PRODUCTION PARTNERS OVERSEAS

MCDONNELL-DOUGLAS DC-X-200

- SCALED-DOWN DC-10, NEW WING, 2 ENGINES
- COST \$500-600M TO GET INTO PRODUCTION

BOEING 7X7

- LEAN TOWARD TRI-JET
- COST \$1B TO DEVELOP

FOREIGN COMPETITION

- 250 SEAT A-300 —————> SHRINK TO 200 SEATS
- 100 SEAT MERCURE —————> STRETCH TO 150 SEATS

1/ BUSINESS WEEK, 12 APRIL 1976.

SPECIFIC MULTILATERAL DEVELOPMENTS

BOEING 7X7

- GREW OUT OF QSH PROJECT WITH AERITALIA (JOINT MANUFACTURING/ MARKETING AGREEMENT IN MAY 1971)
- CURRENT PROGRAM GIVES ITALIAN CONSORTIUM PRODUCTION PARTICIPATION
- BOEING STATEMENT SAYS AERITALIA HAS 20% OF PROGRAM
- IF CFM 56 ENGINE SELECTED, FRENCH WILL HAVE 50% OF ENGINE PROGRAM
- IF JT10D ENGINE SELECTED, GERMANY AND ITALY WILL PARTICIPATE IN POWERPLANT DEVELOPMENT AND PRODUCTION
- JAPAN (MITSUBISHI CONSORTIUM) TRYING TO JOIN PROGRAM, AFTER DROPPING OWN YX TRANSPORT PROGRAM
- COULD INVOLVE COOPERATIVE EFFORT ON NEW WING TO BE USED BOTH ON 7X7 AND A-300B TRANSPORT
- TIMETABLE: FIRST 7X7 IN 1980-82 PERIOD; GENERALLY A DERIVATIVE OF 727

SOURCE: DMS MARKET INTELLIGENCE REPORT, SEPTEMBER 1975
AVIATION WEEK, 16 FEBRUARY 1976

SPECIFIC MULTILATERAL DEVELOPMENTS (CONT)

DOUGLAS/DASSAULT-BREGUET

- DOUGLAS BUILDS FUSELAGE BARREL EXTENSION AND PROVIDE TECHNICAL AND SALES SUPPORT FOR MERCURE 200
- DASSAULT FUND DEVELOPMENT OF HIGH-ASPECT-RATIO WING FOR DC-X-200

DOUGLAS/AEROSPATIALE

- COOPERATIVE VENTURE ON ADVANCED VERSIONS OF A-300B TRANSPORT

LOCKHEED/DASSAULT-BREGUET

- NEW WING/POSSIBLE ENGINE CHANGE FOR MERCURE 200
- POSSIBLE USE IN U.S. MARKETS

GE/SNECMA

- CFM INTERNATIONAL, A JOINT COMPANY (FOUNDED IN 1974)
- CFM 56 ENGINE
- IDEAL FOR BAC 111, DC-9, MERCURE, 727, TRIDENT, A300, 707, DC-8-60
- 50/50 SPLIT, OVERALL PROGRAM MANAGEMENT AND SINGLE CUSTOMER INTERFACE FOR SALES AND SERVICES

P&W/ROLLS ROYCE, ETC.

- CONSORTIUM TO MANUFACTURE JT10D-2 10 TON ENGINE
- COMPETE WITH CFM56

RATIONALE FOR MULTILATERAL AGREEMENTS
FOR AIRCRAFT MANUFACTURER

- REDUCE/SHARE RISK
- REDUCE FRONT END CASH FLOW
- EXPAND MARKETS
- GARNER FOREIGN TECHNOLOGY

SUMMARY OF FAVORABLE/UNFAVORABLE ASPECTS AT NATIONAL LEVEL

FAVORABLE

- EXPANDED SALES AND POSITIVE CONTRIBUTION TO BALANCE OF PAYMENTS
- MAINTENANCE OF HEALTH OF FREE WORLD FOREIGN AIRCRAFT INDUSTRY
- COOPERATION— FOREIGN POLICY IMPLICATIONS

UNFAVORABLE

- POTENTIAL LOSS OF SALES, JOBS AND INVESTMENT TO FOREIGN COMPANIES
- TRANSFER OF R&T TO FOREIGN COMPANIES (A TWO-WAY STREET)
- POTENTIAL NEGATIVE BALANCE OF PAYMENTS EFFECTS

SELECTED PREVIOUS STUDY RESULTS

GENERAL INDUSTRY

- CHARACTERISTICS OF R&D INTENSIVE INDUSTRY
- ECONOMIC BENEFITS OF TECHNOLOGY TRANSFER
- CONCLUSIONS

AVIATION INDUSTRY

- TRENDS
- EFFECTS
- CONCLUSIONS

SOME SELECTED STUDY RESULTS ^{1/}

- OVERSEAS ACTIVITIES BY U.S. FIRMS ARE BENEFICIAL ^{2/}
 - THEY INCREASE EXPORTS AND STIMULATE DOMESTIC EMPLOYMENT
 - PROVIDE MEANS OF ACQUIRING FOREIGN TECHNOLOGY
- FIRMS DO PREFER EXPORTS TO FOREIGN DIRECT INVESTMENTS AND FOREIGN DIRECT INVESTMENTS TO LICENSING ^{3/}
- U.S. MANUFACTURING INDUSTRIES WITH RELATIVELY LARGE R&D EXPENDITURES LEAD OTHER INDUSTRIES IN EXPORTS, FOREIGN INVESTMENT AND LICENSING
- THERE IS NO CLEAR-CUT RELATION BETWEEN FOREIGN DIRECT INVESTMENT AND "R&D INTENSIVENESS" OF INDUSTRIES; IN CONTRAST, INTERNATIONAL LICENSING TENDS TO VARY DIRECTLY WITH "R&D INTENSIVENESS" ^{4/}

-
- 1/ NATIONAL SCIENCE FOUNDATION, TECHNOLOGICAL INNOVATION AND FEDERAL GOVERNMENT POLICY, JANUARY 1976.
 - 2/ M. WILKINS, THE MATURING MULTINATIONAL ENTERPRISE: AMERICAN BUSINESS ABROAD FROM 1914 TO 1970, CAMBRIDGE, HARVARD UNIVERSITY PRESS, 1974.
 - 3/ NATIONAL SCIENCE FOUNDATION, THE EFFECTS OF INTERNATIONAL TECHNOLOGY TRANSFERS ON U.S. ECONOMY, PAPERS AND PROCEEDINGS OF A COLLOQUIUM IN WASHINGTON, D. C., 17 NOVEMBER 1973.
 - 4/ G. HAWKINS, TECHNOLOGY TRANSFER AND MULTINATIONAL FIRMS: THE HOME COUNTRY PERSPECTIVE, NEW YORK UNIVERSITY, UNPUBLISHED PAPER, 1975.

SOME SELECTED STUDY RESULTS 1/

- PAYMENTS FOR LICENSED TECHNOLOGY (ALL— IN U.S.) ARE ABOUT 4% OF TOTAL RETURNS TO INNOVATIVE EFFORT (FRACTION OF LICENSED PATENTS CONSIDERABLY HIGHER)
- FIRMS TEND TO LICENSE THEIR TECHNOLOGY INTERNATIONALLY MORE READILY THAN DOMESTICALLY
- REASON— PROTECTION OF DOMESTIC MARKETS; RETURN IN MARKETS CANNOT ENTER ABROAD
- RULE-OF-THUMB: LICENSORS GET ABOUT 25% OF PRODUCTION PROFITS OR COST-SAVINGS ATTRIBUTABLE TO THEIR INVENTION
- ROYALTY PAYMENTS FOR AN INVENTION ARE WELL BELOW VALUE OF INVENTION TO LICENSEE

NOTE: RESULTS ARE BASED UPON STUDY OF U.S. AND JAPAN DATA.

1/ R.W. WILSON AND M.J. PECK, THE SALE OF TECHNOLOGY THROUGH LICENSING, DEPARTMENT OF ECONOMICS, YALE UNIVERSITY (SPONSORED BY NSF), PB 244-158, MAY 1975.

SOME SELECTED STUDY RESULTS

- FOREIGN DIRECT INVESTMENT^{1/} MAKES A SMALL CONTRIBUTION TO INTERNATIONAL DIFFUSION OF TECHNOLOGY
 - MAJOR PORTION OF SUCH INVESTMENT IN MANUFACTURING OCCURS AMONG INDUSTRIAL COUNTRIES WHERE COMPETITIVE DOMESTIC FIRMS ALREADY EXIST
- AVAILABLE KNOWLEDGE INADEQUATE FOR ASSESSING WHETHER U.S. ECONOMY, ON NET, BENEFITS FROM INTERNATIONAL TECHNOLOGY TRANSFER; MANY SPECIFIC INDUSTRIES, IN U.S. AND OVERSEAS, HAVE BENEFITTED^{2/}
- AVAILABLE EVIDENCE SUGGESTS THAT THE U.S. SHOULD MAINTAIN ITS PRESENT POLICY PERMITTING FOREIGN DIRECT INVESTMENT AND LICENSING RELATIVELY FREE OF RESTRICTIONS^{3/}
 - EXCEPT FOR NATIONAL SECURITY CONSIDERATIONS
 - NO EVIDENCE, ON NET, THAT THESE HAVE HURT U.S. ECONOMIC WELFARE

1/ W. F. FINAN, THE INTERNATIONAL TRANSFER OF SEMICONDUCTOR TECHNOLOGY THROUGH U.S.-BASED FIRMS, NBER, 1975; ALSO A. LAKE, A STUDY OF THE INTRODUCTION OF INNOVATIONS INTO THE U.K. ECONOMY, NSF GRANT, 1975 (UNPUBLISHED PAPER).

2/ G. C. HUFBAUER AND F. M. ADLER, OVERSEAS MANUFACTURING INVESTMENT AND THE BALANCE OF PAYMENTS, TAX POLICY RESEARCH STUDY NO. 1, U.S. DEPARTMENT OF TREASURY, 1968; C. FREEMAN, R&D IN ELECTRONIC CAPITAL GOODS, NATIONAL INSTITUTE ECONOMIC REVIEW, VOL. 34, NOVEMBER 1965.

3/ NATIONAL SCIENCE FOUNDATION, THE EFFECTS OF INTERNATIONAL TECHNOLOGY TRANSFERS OF U.S. ECONOMY, PAPERS AND PROCEEDINGS OF A COLLOQUIUM IN WASHINGTON, D. C., 17 NOVEMBER 1973.

SOME SELECTED STUDY RESULTS ^{1/}

- EFFECT OF TRANSFERRING TECHNOLOGY WITH A LONG LEAD TIME TO PRODUCTION MUST BE VERY LOW
- OPEN LITERATURE ASSURES THAT BREAKTHROUGHS WIDELY DISSEMINATED
- TRANSFER OF LONG LEAD TIME BASIC/APPLIED RESEARCH IS PROBABLY BENEFICIAL
- TRANSFER OF MANUFACTURING EXPERTISE OR TECHNOLOGY WITH SHORT LEAD TIME TO PRODUCTION CAN HAVE EFFECT ON COMPETITIVE CAPABILITIES OF A FIRM
- LICENSING FEES CAN PROVIDE FUNDS IN U.S. FOR FURTHER DEVELOPMENT
 - E.G., MANUFACTURE OF ENGINES (GE-SNECMA)
 - TEND TO COUNTERBALANCE GAINS BY FOREIGN MANUFACTURER IN LEARNING ABOUT OUR MANUFACTURING TECHNOLOGY
- U.S. RECEIVES INFORMATION AND FUNDS WHEN TECHNOLOGY SHARED

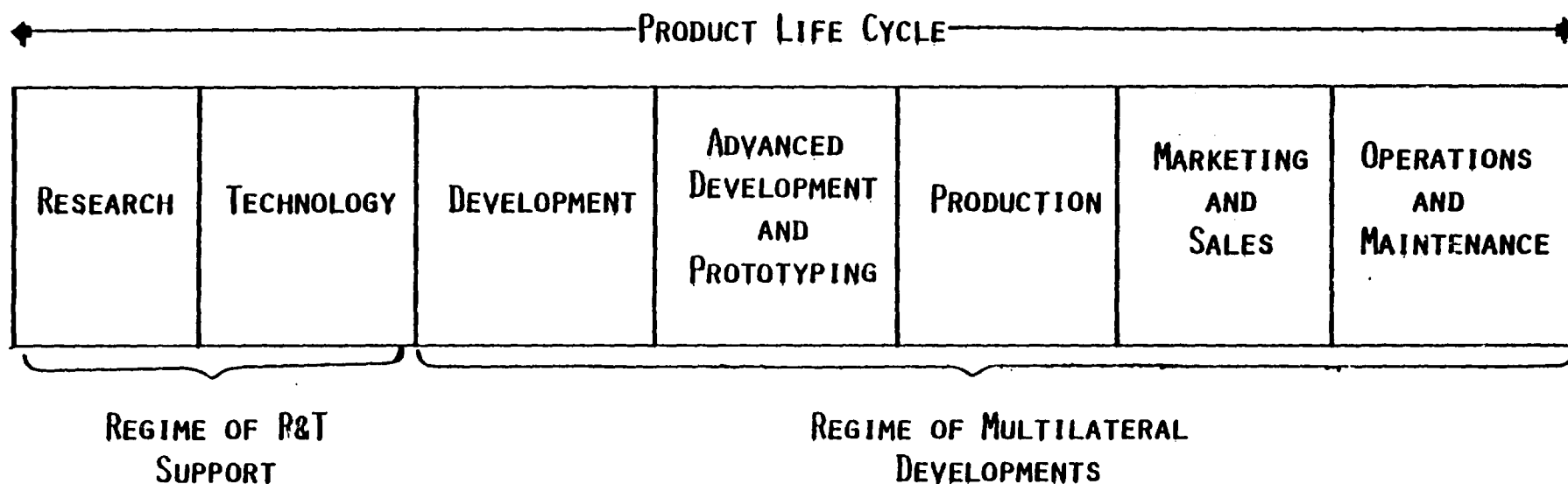
1/ BOOZ-ALLEN APPLIED RESEARCH, INC., COMPETITIVE FACTORS IN WORLD CIVIL AVIATION, NASA CR-114447, AUGUST 1972.

SOME SELECTED STUDY RESULTS 1/

- IF CURRENT TRENDS CONTINUE, U.S. WILL LOSE OUT IN MEDIUM AND SHORT HAUL AIRCRAFT MARKET
 - OUTRIGHT SUBSIDIES OF FOREIGN INDUSTRY
 - DECREASE IN TECHNOLOGY TRANSFER FROM MILITARY SECTOR IN U.S.
- FAVORABLE EUROPEAN POSITION NOT DUE TO INFUSIONS OF AMERICAN TECHNOLOGY
 - DEVELOPMENT TRENDS PROCEEDED IN PARALLEL WITH LITTLE CROSSOVER
 - AMERICAN POSITION PROBABLY BEEN MORE FAVORABLY AFFECTED BY ANY INTERCHANGE DUE TO GREATER ABILITY TO APPLY TECHNOLOGY
- MOST EFFECTIVE INTERCHANGE OF TECHNOLOGY ON INTERPERSONAL BASIS
 - LITTLE EVIDENCE OF ANY EFFECTS OF SUCH EXCHANGE IN AVIATION INDUSTRY
- U.S. SHOULD ADOPT POLICIES SUPPORTING R&D ON TECHNOLOGY INTENSIVE INDUSTRIES
- U.S. AVIATION INDUSTRY PROBABLY BENEFITTED FROM ANY EXCHANGE OF TECHNOLOGY RATHER THAN SUFFERED

1/ FORECASTING INTERNATIONAL, LTD., HOW TECHNOLOGY TRANSFER AFFECTS THE COMPETITIVE POSITION OF THE U.S. IN THE WORLD AVIATION MARKET, NASA CR-114448, 3 MARCH 1972.

MULTILATERAL DEVELOPMENTS AND R&T SUPPORT OPERATE IN DISPARATE REGIMES



- R&T SUPPORTS REMAINDER OF PRODUCT LIFE CYCLE
- R&T GENERALLY PRECEDES PRODUCTION BY 5-15 YEARS
- SOME R&T MAY HAVE SHORT LEAD TIME (1-3 YEARS) E.G.,
MANUFACTURING/PRODUCTION PROCESSES

CONCLUSIONS

- MOST PRODUCTS/SERVICES INVOLVED IN MULTILATERAL DEVELOPMENTS BASED ON "OLD" OR WELL KNOWN R&T RESULTS
- SOME (LIMITED NUMBER) OF PRODUCTS/SERVICES INVOLVED IN MULTILATERAL DEVELOPMENTS MAY BE BASED UPON "NEW" OR RECENT R&T RESULTS (E.G., MANUFACTURING/PRODUCTION PROCESSES)
- TO THE EXTENT THAT RECENT R&T RESULTS ARE TRANSFERRED, PAYMENTS ARE RECEIVED VIA LICENSING AND OTHER SIMILAR ARRANGEMENTS
- R&T RESULTS IN GENERAL ARE PRODUCED IN A HIGHLY DYNAMIC MANNER AND REPRESENT A HIGHLY FUNGIBLE COMMODITY (E.G., PEOPLE TRANSFER, OPEN LITERATURE, ETC.)
- STRENGTH OF U.S. COMPANY BARGAINING POSITION DEPENDS ON POSSESSION OF ADVANCED TECHNOLOGY

SUMMARY

- MULTILATERAL AERONAUTICAL DEVELOPMENTS INEVITABLE BASED ON CURRENT U.S. POSITION AND INTERNATIONAL TRENDS
- DIRECT TRANSFER OF R&T OCCURS VIA PATENTS/LICENSING FOR WHICH PAYMENTS ARE RECEIVED
- POTENTIAL FOR "INADVERTENT" TRANSFER LIMITED SINCE OPERATE IN DISPARATE REGIMES OF LIFE CYCLE, WITH TIME DELAYS
- HOWEVER, SOME THREATS EXIST IN SHORT LEAD TIME AREAS (E.G., MANUFACTURING/PRODUCTION PROCESSES)
- R&T RESULTS INEVITABLY TRANSFERRED AS HIGHLY FUNGIBLE COMMODITY
- PREVIOUS STUDIES SUGGEST
 - AVAILABLE KNOWLEDGE INADEQUATE FOR CONCLUSIVE NET BENEFIT STATEMENT
 - U.S. SHOULD MAINTAIN PRESENT POLICY

PRELIMINARY RECOMMENDATIONS
FOR
U.S. AERONAUTICAL R&T POLICY

- NO FUNDAMENTAL CHANGE IN CURRENT POLICY (LONG LEAD TIME R&T)
- CAREFUL EXAMINATION NEEDED FOR SHORT LEAD TIME R&T
- U.S. SHOULD FACE ROLE AS EXPORTER OF R&T AND IMPLICATIONS OF THAT ROLE
 - CONTINUOUS GENERATION OF R&T
 - FAIR MARKET VALUE OF R&T

SELECTED SUMMARY TABULATIONS
AND ARTICLES

MULTILATERAL AERONAUTICAL DEVELOPMENTS

STATUS REPORT/BRIEFING
27 APRIL 1976

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SUBSIDIZATION TO AEROSPACE INDUSTRY
COMPARATIVE ASSESSMENT OF MAJOR EUROPEAN
COUNTRIES AND UNITED STATES

	United States	France	West Germany
Government Ownership	No U.S. Government ownership.	About 50% of the French aerospace industry is government-owned. Aerospatiale and SNECMA are wholly government-owned.	No substantial holdings of the major aircraft companies in Germany. Bavarian Government owns about 6% of MBB.
Government Encouraged Concentration	Has not sought merger of U.S. aerospace companies.	In January 1970, the nationalized Sud-aviation and Nord-aviation merged with nationalized SEREB to form Societe Nationale Industrielle Aerospatiale. Breguet aviation merged with Avions Marcel Dassault in 1967 after government pressure. Dassault is France's largest private aerospace company.	Under government pressure, mergers have consolidated the industry into 4 major complexes: Dornier, MBB, MTU, and VFW-Fokker (German-Dutch Co.). These four companies collectively control 95% of Germany's aerospace capacity.
Multi-national Projects	U.S. aerospace companies have licensed production of U.S. aircraft abroad. Aeritalia and Boeing are jointly developing QSH transport; SNECMA and GE are jointly developing new engine; the U.S. Government is not involved directly or indirectly in funding the U.S. share of multinational projects.	Aerospatiale with Britain's BAC jointly developing Concorde; Aerospatiale with German, Dutch, Spanish and British companies developing A-300B Airbus; Aerospatiale with Britain's Westland on new helicopters; Aerospatiale with VFW and MBB of Germany on Transall; Dassault and BAC jointly developing Jaguar; Dassault/Breguet with Dutch, Belgian, and German companies on Atlantic; Dassault/Breguet with Dornier of Germany on Alpha jet; Dassault/Breguet with Italian, Belgian, and Spanish companies jointly developing Mercure; SNECMA and General Electric developing new engines.	MBB, VFW-Fokker, and Dornier have teamed with Aerospatiale on Airbus; VFW-Fokker will use Rolls/Royce engines on VFW-614; BAC and Aeritalia joined MBB for MRCA development; Dornier and Dassault evenly split work on Alpha jet program which is monitored by joint French-German government representatives; VFW and MBB joined with Aerospatiale on Transall.
Government Subsidies	Besides the U.S. guaranteed loan of \$250 million to Lockheed and development costs of the SST, the U.S. Government has provided no direct support for commercial aircraft development, production or sales ventures except through the application of military and NASA research and development, Eximbank loans and guarantees, and tax deferrals through Domestic International Sales Corporations (DISC).	France and U.K. are splitting Concorde costs estimated at \$3.0 billion (by 1975); \$192 million is estimated French share of A-300B development costs; State has loaned Dassault 55% of Mercure's \$200 million development costs; Government is funding SNECMA's half of joint GE/SNECMA project. These government subsidies for production are in the form of loans which become repayable if and when sufficient sales and profits are realized. In 1972, France had budgeted \$158.2 million for the Concorde, \$31.3 million for the Mercure, and \$64.5 million for the A-300B Airbus.	Government has granted \$380 million for its share of A-300B Airbus development, and guaranteed bank loans for additional sums; with subsidies and credit, the government has funded 75% of total VFW-614 project; Government has invested nearly \$300 million on VSTOL studies; government grants loans of up to 60% of development costs. These loans bear no interest, and their repayment is contingent upon the profitability of the project. State aid to civil aircraft production totaled \$60.3 million (1963-69), \$52 million in 1970, \$52 million in 1971, \$62 million in 1972, and \$62 million for 1973. \$57 million was allocated for A-300B in 1972.
R&D	U.S. expenditures for aerospace R&D totaled \$5,051 million in 1973; the government funded 78.4% of that total.	French expenditures for aerospace R&D in 1967 totaled \$694 million; the State funded 92.8% of that total.	German expenditures for aerospace R&D totaled \$194 million in 1967; the government funded 96.9% of that total.
Marketing Assistance	Eximbank extends 10-year financing for widebody aircraft; Exim plans to participate up to 90%, including loans and guarantees on narrowbody aircraft when foreign competition is confirmed; current Eximbank rate is 7%. Generally, competitive terms are offered under Foreign Military Sales Program. DISC enacted in 1971 permits firms to be more competitive on the export market by a tax deferral of 50%.	The State has made it possible for Dassault to offer credit terms for its military aircraft as low as 3% on periods over 15 years. In Latin America, industry salesmen are often accompanied by representatives of the French ministries of finance, science and technology, and defense; the State supports Dassault production offers to other countries (offset arrangements).	Government and Hermes (German export insurance bank) have exempted VFW-614 from normal sales terms. Payment may be financed on 10-year loan at a rate of 2% below existing market rate. Generally, tight export financing regulations and export controls to all but NATO countries except Greece impose impediments for aircraft export.
State As A Customer	The State is one of the principal customers of the aerospace industry. In 1974 the State accounted for 50.3% of the total sales. The percentage is high because of missiles and spacecraft.	The State is one of the principal customers of the aerospace industry. In 1972 the State accounted for 49.5% of the total sales.	The State is one of the principal customers of the aerospace industry. In 1972 the State accounted for 37.3% of the total sales.

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Italy	United Kingdom
50% of Aeritalia is government-owned. Aeronautica Macchi, Siai-Marchetti, Augusta, and Partenavia are privately owned.	Rolls-Royce is government-owned; because BAC was 20% owned by Rolls-Royce, the government has assumed this share, but intends to sell it; government has large holdings in two smaller companies--Beagle Aircraft Co., and Short Brothers and Harland Ltd.
Aeritalia was formed in July 1971 by combining aerospace activities of Fiat, and Aefer and Salmofraghi. Would like a merger of Siai-Marchetti, Augusta and Macchi.	In late 1950's and early 1960's: BAC, Hawker Siddeley, Westland (helicopters), and Rolls-Royce.
Aeritalia holds 15% share of MRCA development with BAC of U.K. and MBB of Germany; Aeritalia is involved in licensed production programs on DC-9 and DC-10, and with Boeing on development of new quiet short-haul transport; Fiat (part of Aeritalia) involved in Mercure development, and has assembly facilities for the Lockheed F-104S; Macchi joined BAC, MBB, and Aeritalia in development of the Panop light fighter; Augusta, under license, produces and sells Bell helicopters.	BAC with France on Concorde; Hawker Siddeley involved in Airbus project; Rolls-Royce and SNECMA sharing development costs of engine for VFW-614; BAC, MBB of Germany, and Saab-Scania of Sweden--joint development of QSTOL; BAC with Dassault jointly developing Jaguar; Westland with Aerospaziale on helicopters; BAC with Germans and Italians on MRCA. Short Brothers share development costs of Fokker F-28 with Dutch; Hawker Siddeley collaborates with Beech on further development of HS-125 family.
The decision to form Aeritalia was the first move by the government to give significant support to its aerospace industry. Recent government instability has caused delays in establishing priorities. Government is financing Italy's participation in MRCA development. Government will spend \$280 million through Aeritalia in developing and manufacturing a 4-engine, 150-passenger QSH transport.	U.K. and France are splitting Concorde R&D costs estimated at \$3.0 billion (by 1975); Government is funding 60-80% of U.K.'s share of VFW-614 costs estimated at \$2-3 million; Government participation in MRCA program approximates \$600 million, and amounts to \$28 million for Jaguar; British companies may write off 100% of new investments in aerospace production facilities in the year in which investments are made. Besides R&D support, the Government assists industry with "launching" aid. Launching aid is an interest-free financial contribution to the launching costs of a civil aircraft or aero-engine project, repayable as a levy on sales and licenses to the extent that these are achieved. A tax rebate of 1% of purchase price has been rebated by the government on all exports (amounts to cash subsidy). State subsidies for civil aircraft production totaled \$82 million in 1966, \$143 million in 1967, \$168 million in 1968, \$192 million in 1969, and \$192 million in 1970.
In 1967 Italian expenditures for aerospace totaled \$38 million; government funded 81.5% of that total.	British expenditures for aerospace R&D in 1968 totaled \$726 million; the State funded 92.1% of that total.
Under \$50 million of aircraft products were exported in 1971. The Italian Airforce buys 2/3 of the country's aerospace products which totaled \$238 million in 1971. Less than 10% goes to the domestic civil market.	BAC has sold BAC-111's at 5% down, 5% on delivery, and 10-year financing at 5.5% interest; Hawker Siddeley 748's have been sold to Chile with no down payment and financing for 12 years.
The State is one of the principal customers of the aerospace industry. In 1972 the State accounted for 53.4% of the total sales.	The State is one of the principal customers of the aerospace industry. In 1972 the State accounted for 47.3% of the total sales.

Designation	Type	Mission	Participating Foreign Manufacturers	Cooperative Agreement	Comments
Boeing YX	Trijet	Short-haul transport	Japanese Civil Transport Plane Development Assoc.	The 1972 Japanese budget cut the planned money available for the year down from ¥3,300 million (¥4.1 million) to only \$200 million (¥250,000). ¹	The agreement negotiated a 50-50 venture but in 1974 Japan merged with Boeing/Aeritalia on the 7X7 project. Japanese participation could now be as little as 20%.
Boeing 7X7 (exploratory)	Trijet, 4 engine	Long-range, low density routes, transport	Aeritalia, Italy Japan	Japanese government voted \$7 million to cover 75% of budget for FY 1975. Originally planned as a STOL type early in 1971 (OSH) in May. By the end of 1973, R&D expenditures by Aeritalia amounted to \$32 million.	(James All the World Aircraft 1975-1976.) Aeritalia requested that its share be cut to 20% from 50% in 1974, thus suggesting a 30/70 share for the Japanese. ² Boeing is also interested in British participation. ³
Boeing 7N7	Family of aircraft	Medium range		Italian government has set aside, in principle, some \$340 million for the project.	Hopes to build 700 by 1986. ⁴ Boeing has a May 1976 goal for clarifying the standard body derivatives being studies under the label of 7N7. ⁵
Boeing 707	4 engine jet, passenger liner	Long-range passenger/freight transport	Northwest Industries Ltd. (Canada) Northwest Industries Ltd.	January 1973-To build and deliver aft fuselage sections, 55 center wing structures. Contract valued at \$5 million. Nov. 1972-Tail sections contract valued at \$6 million, calls for 35 shipsets with an option for 30 more over 18 months.	Contract calls for deliveries over next four years. ⁶ Contract for 2.5 years. ^{5,7}
Boeing 727	Trijet turbofan airliner	Short/medium range commercial aircraft operations	CASA of Spain Soviet Union	January 1973-To supply rear airstair assemblies and rudder tabs. USSR to produce passenger door as per 1971 negotiations.	Boeing will supply technical assistance and tooling equipment. Boeing turned over set of drawings and tooling diagrams. ⁸ Sold Boeing technology on 727 door. ⁹
Boeing 727-200			Hawker de Havilland & Commonwealth Aircraft Corp. (Australia)	1971 contract for main wing ribs and rudders totalling nearly \$4 million. Galleys for 8 aircraft contract valued at \$300,000.	Hawker de Havilland has received an additional contract valued at \$2 million. This is the 6th such contract in 5 yrs. Boeing has placed orders for almost 350 shipsets valued at \$15 million. ¹⁰
Boeing 737	Twin-engined jet transport	Short-range commercial airline operations		Advanced 737 delivered to Sandia Arabian Airlines March 1971.	
Boeing 747	4-engine	Long range, heavy load, passenger/cargo airline operations	Mitsubishi Heavy Industries; Kawasaki Heavy Industries Short Brothers & Harland (Belfast) C. T. Taylor, Ltd. (England) Marconi-Elliott Avionic Systems, Ltd.	Inboard flaps; outboard flaps. ¹¹ March 1973-Undercarriage doors in excess of £1 million (about \$2.46 million). ¹² September 1974-Three aircraft sets of galleys valued at £3/4 million. ¹³ Working on an improved automatic throttle control system. ¹⁴ Note: Boeing would place 152 employees in Baghdad in the summer of 1975 under a support contract with Iraq Airways Ltd. The company would provide management assistance to Iraqi Air for 3 years under the \$20 million support program which was a condition of a purchase by the airlines of 8 Boeing jetliners January 31, 1975. ¹⁵	

U.S. COOPERATIVE AGREEMENTS WITH FOREIGN AND MULTINATIONAL FIRMS IN CIVIL AIRCRAFT AND ENGINE PROGRAMS

Designation	Type	Mission	Participating Foreign Manufacturers	Cooperative Agreement	Comments
Lockheed			Hawker de Havilland Australia Pty. Ltd. & Commonwealth Aircraft Corp.	September 1975-Lockheed Aircraft (Australia) Pty. Ltd. subsidiary, said that it had signed contracts worth \$4,000,000 with Hawker de Havilland Australia Pty. Ltd. and Commonwealth Aircraft Corp. to supply airframe structures for L-1011 aircraft.	The unit said that the contracts were part of an aircraft purchase offset deal it submitted with its successful bid for the sale of Orion aircraft to the Australian Air Force earlier in that year.
Lockheed L-1011 Tristar	3-engine	Medium haul, airbus. Commercial airliner. High density, intermediate range airline passenger operations	Short Brothers & Harland (Belfast) Scottish Aviation, Prestwick	January 1973-Galley doors and tail rib assemblies £2 million order. February 1973-Cargo and access doors and flight deck escape hatches - £1 million contract.	Short Brothers had previously built engine pods, undercarriage doors and flight components for the Tristar. ¹⁶ Will be in production well into the 1980s. ¹⁷
Lockheed			Hellenic Aerospace Industries (HAI), an overhaul and maintenance facility for Greek military and commercial aircraft.	December 1975-\$120 million contract for construction and management of a support facility to be located near Athens.	Lockheed Aircraft, International will manage the facility. Lockheed Aircraft Services will provide personnel to operate it. ¹⁸
Lockheed P-3 LRPA (long-range patrol aircraft)		Combined military/civilian mission capability	Canadian Forces	December 1975-Civilian sensor canisters which can be installed overnight will enable crews to fly pollution and resource control, aerial mapping and ocean surveillance missions as well as ASW missions.	Canada ordered 18 P-3 LRPAs in a buy valued at an estimated \$750 million over the lifetime of the program. ¹⁹
McDonnell Douglas			Rohr Industries, U.S.A., and France	September 1972-Contract for assembly of up to 125 shipsets of pad assemblies for GE CF6-80 jet engines to power A300B. Contract valued at \$27.5 million.	The Rohr contract runs to the fall of 1976. First 5 sets to be built at Chula Vista. Final engine build-up at Toulouse, France. ²⁰
OC9		Passenger/cargo	Canada France	Offering Canada substantial amount of component structures work on the OC9 and OC10. ²¹ Douglas would build fuselage barrel extension for Dassault-Breguet and provide technical and sales support. ²²	
OC10		All purpose jet	United Kingdom	Offering work on OC10 worth 318 million pounds sterling and 10,000 jobs over a period of 10 years. Propose 30% British production (engines, pylons, nacelles and avionics). ²³	
Rockwell International Corp.	Commander 700, twin engine, pressurized transport	Business aircraft, light executive transport	Fuji Heavy Industries (Japan)	July 1974-Agreement signed. Two piston business aircraft to cost about \$10 million. 60% cost to Fuji; 40% to Rockwell.	Prototype designed and built under a joint development program. ²⁴ Rockwell is already studying turboprop and jet-powered versions. ²⁵
Grumman Gulfstream X	3-4 engine configurations				Preliminary studies being made and company is discussing suitable power plants with U.S. and foreign turbofan manufacturers. ²⁶
Hughes Airwest and TOA Domestic Airlines			Lease of two McDonnell Douglas OC9-30 twinjets	September 1973-Reached agreement to provide Japanese airline with jet maintenance training and leased aircraft.	

U.S. COOPERATIVE AGREEMENTS WITH FOREIGN AND MULTINATIONAL FIRMS IN CIVIL AIRCRAFT AND ENGINE PROGRAMS

Designation	Participating Foreign Manufacturers	Comments
Hughes Airwest & Saudi Arabian Airlines	Hughes Airwest is operating a domestic airline for the nation replacing the DC-3 operation	April 1975-Involves 33 employees and least of three F-27s.
LTV Aerospace Corp.		Preliminary agreement signed with Compagnie Central d'Etudes Industrielle of Paris, giving the French company exclusive marketing rights in France for LTV's Airtrans people/baggage/mail automated transportation system. ²⁷

¹ Flight International, February 3, 1972, p. 161.

² Department of State Airgram - A-271, May 8, 1974.

³ Department of State Airgram - A-540, August 14, 1974.

⁴ Flight International, February 1973.

⁵ Aviation Week & Space Technology, February 16, 1976.

⁶ Department of State Airgram - A-173, April 11, 1973.

⁷ Aviation Daily, November 30, 1972, p. 166.

⁸ New York Times, August 25, 1972.

⁹ Aviation Week & Space Technology, March 12, 1973, p. 26.

¹⁰ Aviation Daily, December 15, 1972, p. 255.

¹¹ Aviation Daily, December 4, 1973, p. 182.

¹² Aviation Daily, March 22, 1973, p. 127.

¹³ Society of British Aerospace Companies, Ltd (SBAC News), London, September 19, 1974.

¹⁴ Aviation Daily, June 5, 1975, p. 198.

¹⁵ Standard & Poors, April 24, 1975.

¹⁶ SBAC News, March 22, 1973.

¹⁷ SBAC News, March 8, 1973 and Aviation Daily, February 26, 1973, p. 303.

¹⁸ Aviation Week & Space Technology, December 8, 1975, p. 201.

¹⁹ Aviation Week & Space Technology, December 15, 1975, p. 46.

²⁰ Aviation Daily, September 21, 1972, p. 110.

²¹ Aviation Daily, October 3, 1975, p. 189.

²² Aviation Week & Space Technology, February 2, 1976.

²³ Aviation Daily, December 29, 1975, p. 302.

²⁴ Aviation Dailies: July 16, 1974, p. 86; July 30, 1974, p. 167; and Aviation Week & Space Technology, July 22, 1974, p. 18.

²⁵ OMS Civil Aircraft Highlights, December 1975.

²⁶ Aviation Week & Space Technology, September 9, 1974, p. 55.

²⁷ Aviation Week & Space Technology, July 17, 1972, p. 11.

ENGINE PROGRAMS

Manufacturer	Designation	Mission	Foreign Aircraft	Comments
Avco Lycoming	ALF 5020 IGSO-540A/C	Commercial light transport and executive market Business/Transport	1971-Dassault-Breguet Falcon 30 Hawker Siddeley HS146 Rinaldo Piaggio - Italy	A contender for the next generation of turbofan-powered business aircraft (Aviation Week and Space Technology, 12/1/75, p. 11)
Garrett Airesearch	331-1-1S1A 331-2-201A 331-5-251C 731-3	Business Executive Cargo/Passenger STOL Transport Business jet	Japanese Mitsubishi MU2F & 2G Irish Short Skyvan SC7 Series Casa 212 - Spain's Aviocar Israel's Westwind 1124	
General Electric/SNECMA ● (CFM International, a joint company was formed by General Electric & SNECMA in early 1974 to provide overall program management for the CFM 56 engine, and a single customer interface for sales and service)	CFM-56 engine Third generation subsonic aircraft	Commercial aircraft	Ideal for English BAC 111 Ideal for France Mercure	SNECMA decided in autumn of 1971 to develop engine on a SC/50 basis with General Electric. In 1971, 1.2 million francs, and in 1972, 10 million francs. 80 million francs in contracting authority and 61.7 million francs in appropriations had been earmarked for 1974 for the 10-ton engine for development costs apart from SNECMA's own financing input. (Department of State Airgram A-250, December 13, 1973).
General Electric/SNECMA/MTU ●	CF6-50 turbofan		French and German Airbus Industries A300B2 and 34 programs	Of the development costs, SNECMA manufacturers parts totalling 22% of the cost; MTU, 11%; General Electric, 61.3%; SNECMA at Corbeil & Villaroche, 5.7%.
Pratt & Whitney ●	JT100	Commercial aircraft	Designed to power the 4-engined Airbus, Boeing 7X7	Export of jet-engine technology through joint venture with MTU, W. Germany, and an Italian Group formed by Fiat and Alfa Romeo. Total program development cost is estimated at \$300 million.
Pratt & Whitney/ Canada Rolls-Royce ●	JT100-2 10-ton engine	Commercial aircraft		Memorandum of Understanding June 1975. A remote possibility is the development of a second-generation SST engine. The current generation refanned Spay and JT8C are unlikely to become cooperative programs. (Flight International, July 10, 1975, p. 28).
Pratt & Whitney ●	2-R2800 CL215 JT8D-7 SE210 ATL-98	Multi-purpose amphibian Transport Transport Transport Passenger/Cargo	Canadair Ltd, Quebec Aerospatiale, France Caravelle, Super Caravelle Mercure Aviation Trades Ltd. Carvair, England	U.S. Department of Justice may have thrown a damper on the joint development of the RB401 turbofan engine for the business jet market in that it would present serious competitive problems. Cost of development of such a powerplant placed at about \$200 million. (Aviation Daily, January 20, 1976, p. 16).

FOREIGN MAJOR CIVIL COOPERATIVE PROGRAMS

Designation	Type	Mission	Manufacturer	U.S. Technology Export	Status	Comments
-100B, European Airbus (Govt. agreement 5/69; Airbus Industries formed 1970).	Twin-jet airliner	Short/medium range commercial air operations	Airframe: British Aircraft Corp Ltd, England Aerospatiale (SNIAS), France Deutsche Airbus GmbH, German Federal Republic	Pratt & Whitney JT9D-15 turbofan General Electric CF6-50C turbofan (SNECMA and MTU) Garret auxiliary power unit Engine-nacelle commonality with McDonnell Douglas DC10.	Bonn authorities controlling 90% of total development funds; 1,200 million DM (1973 money). A total of 1,500 DM (million) in state guarantees is to be allocated for financing of series production. 23 civil aircraft produced through 1974.	U.S. delivering over 25% of the initial components. Over 50% of the cost of acquisition of spares during the operational life of the aircraft will benefit U.S. industry. Over 200 Airbus plus related spare parts would have to be sold before the CQF can recover the 100 million frs. advanced to SNECMA to help finance adaptation of the GE CF6-50 engine for use on Airbus. French advances to Aerospatiale for French share of airframe development totalled 1.7 billion frs. as of 12/31/74. (Dept. of State Airgram A-341, July 31, 1975).
Aerospatiale SF210, Caravelle 12	Twin-engine	Short/medium range airliner		Pratt & Whitney JT8D-9 turbofan engines		273 Caravelles produced through 1974. Out of production
Aerospatiale A1601, Corvette		Executive transport, air taxi, ambulance, freighter or training aircraft		Pratt & Whitney (UACL) JT15-04 4 turbofan engines		
Corvette 100	Twin-engine jet	Light transport	SNIAS	(United Aircraft of Canada); Pratt & Whitney	Price range \$1.3 to \$1.5 million	
Aerospatiale/BAC Concorde	Supersonic transport		British Aircraft Corp. Ltd (England), Aerospatiale (SNIAS) (France); Rolls-Royce Ltd. (England)	Hamilton-Standard heat exchangers Litton LTH-72 in Air France aircraft comprises three identical inertial platforms		
Assault-reguet Falcon 10 (certificated 9/73)	Twin-turbofan	Liaison, executive transport, aerial photography, ambulance	Avions Marcel Dassault-Breguet Aviation	2 Garret Airesearch TFE 731 turbofan engines	Main market is USA, Falcon Jet Corp, a joint PanAm/Dassault-Breguet operation	A SNECMA/Turbomeca-Larzac-powered version is planned depending on civil development of this engine.
Assault-reguet Falcon 20 (certificated 6/65)	Twin-engine	Executive transport		2 General Electric CF 700-20	Main market is USA Falcon Jet Corp, a joint PanAm/Dassault-Breguet operation	Current production rate is believed to be 1.5 aircraft per month
Assault-reguet Falcon 30/40	Twin-engine	Commuter transport		2 Lycoming ALF502 engines	A development prototype flew in mid-1973, but the program now appears to be moribund.	2 engines first delivered in 1972.
Assault-reguet Falcon 50	Three-engine			Garret Airesearch TFE-73 engines	A new wing will be designated for production aircraft	
Assault-reguet Mercure (certificated early 1974)	Twin-engine	Short-haul transport		2 Pratt & Whitney JT8D-15	Air Inter. sole customer. To be phased out of production.	A growth model powered by 2 General Electric/SNECMA 56 engines has been proposed and could be available by 1978. Government of France had granted 503 million Frs. as of 12/31/74. Lockheed Aircraft Corp and McDonnell Douglas Corp. have been meeting with Dassault-Breguet Aviation for several months as part of a wide-ranging examination of collaboration transport development possibilities involving U.S. and French companies. A deadline of May 1, 1976 has been set. (Aviation Week & Space Technology, 2/15/76).

FOREIGN MAJOR CIVIL COOPERATIVE PROGRAMS

Designation	Type	Mission	Manufacturer	U.S. Technology Export	Status	Comments
<u>Great Britain</u> BN2A-21 Islander	Light transport	Third level/air	Fairley Britten Norman	2 Lycoming 10-540 K185	More than 650 have now been sold. Sales total about 40 from Belgian production.	Current production rate of 10 aircraft per month planned to increase to 12.
BN2A-20 Islander	Light transport	Taxi airlines and		2 Lycoming O-540 E4C5		
BA Mk 3 Island-	Transport	Cargo aircraft		3 Lycoming O-540 E4C5		
Hawker Siddeley HS125-600	Twin-engine	Business	Hawker Siddeley Aviation, Ltd.	Air Research air conditioning and pressurization system. Lockheed landing gear and hydraulic components	337 sold valued at £115 million	Production believed to be running at 1.0 to 1.5 units per month. A reengineed version, to be designated the Series 700 with Garrett Air Research 731 engines is under consideration.
DA-1		Utility/cargo	Lockspeiser Aircraft, Ltd.	1 Lycoming O-540		
SC7 Series Cyvan		Cargo/Passenger	Short Brothers & Harland, Ltd. Belfast	2 Garrett Air Research 331-2-201A		A total of 104 aircraft sold by March 1975 to military & civil customers in about equal proportions. Present production rate about one unit per month.
<u>Netherlands</u> Fokker-VPW F27 Friendship	Twin-engine	Passenger/cargo	Schynhol-Oost, Amsterdam	Auxiliary power systems, temperature controls, wheels and brakes, pneumatic system, auto-pilot, electrical systems, fuel and water methanol pumps, VHF/VOR systems pressurization, APN	204 units ordered from Fairchild which built aircraft under license	
Fokker-VPW F28 Fellowship	Twin-engine	Passenger/cargo	Schynhol-Oost, Amsterdam	Fairchild Hiller, as above	Tri-government agreement mid-1964; Netherlands, U.K. and Germany. Fokker - 57%, England 19%, U. Germany 13 + 11% of manufacture.	
<u>Pakistan</u> Cessna TA-410 (military version of the 172 with an up-rated engine)		Military & x aerial application operations	Kujuski Intl.		In final stages of an agreement under which Hughes Helicopters and Cessna Aircraft would be manufactured in Pakistan. Kujuski International would build 50-70 Cessna, Hughes providing up to 50-5000 and 5000 kits per year for assembly in Pakistan. (Aviation Daily, December 16, 1975)	

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References

1. Aviation Week & Space Technology, February 9, 1976, p. 19.
2. Interavia, September 1975, p. 951.
3. Interavia, July 1975, p. 772.
4. Interavia, June 1975, p. 617.
5. Aviation Week & Space Technology, February 16, 1976, p. 22.

CIVIL JET AIRCRAFT PRODUCTION THROUGH 1974

U.S. Aircraft

Boeing 720 and 707	897
Boeing 727	1,195
Boeing 737	407
Boeing 747	283
Douglas DC-8	(556)
Douglas DC-9	802
Douglas DC-10	240
Lockheed L-1011	150
Convair 880/990	(83)
TOTAL	4,613

European Aircraft

Sud Caravelle	(278)
BAC 111	219
Hawker Siddeley Trident	117
Vickers VC-10	(47)
DeHavilland Comet	(51)
Dassault Mercure	(10)
Aerospatiale/BAC Concorde	9
Airbus A-300B	23
Fokker F-28	95
VFW 614	10
TOTAL	859

NOTE: Numbers in parenthesis out of production.

Table 3

Major Civil Foreign Procurement Programs
by U.S. Aircraft Industry

TRANSPORT MANUFACTURERS

<u>Country</u>	<u>Code*</u>	<u>Program</u>	<u>Item Involved</u>
Australia	P	Boeing 727	Main wing ribs and rudders
Canada	P	Douglas DC-9, DC-10	Wing and tail assemblies (Douglas Canada)
	P	Douglas DC-10	Landing gear
	P	Boeing 707	Aft-fuselage section
	P	Boeing 747	Fiber reinforced plastic assemblies made by Boeing subsidiary
	P	Boeing 707	Wing parts and wing-fuselage attachment assemblies
	P	Boeing 707	Fin and rudder assemblies
	P	Lockheed L-1011	Gas turbine auxiliary power unit
	P	Lockheed L-1011	Hydraulic parts
	P	Lockheed L-1011	Pressure bulkheads and floor structures
	P	Lockheed L-1011	Landing gear doors, engine cowlings, upper bodies
Germany	P	Boeing 737	Wing in spar rib assemblies
Italy	P	Douglas DC-10	Fuselage panels and tail section
	P	Lockheed L-1011	Tailplane parts
Japan	P	Douglas DC-10	Forward passenger, mid- passenger and large cargo doors
	P	Douglas DC-10	Tail assemblies
Spain	P	Boeing 727	Rear air stairs
Switzerland	P	Lockheed L-1011	Vibration monitoring system

* P - Procurement

J - Joint Program

Continued -

Table 3 (continued)

<u>Country</u>	<u>Code*</u>	<u>Program</u>	<u>Item Involved</u>
United Kingdom	P	Douglas DC-10	Landing gear
	J	Lockheed L-1011	Rolls Royce engines
	P	Lockheed L-1011	Control surfaces
	P	Lockheed L-1011	Wing components
	J	Lockheed L-1011	Engine pods
	J	Lockheed L-1011	Cargo and access doors, flights deck escape hatches, galley doors, equipment bay and tail rib assemblies
	P	Lockheed L-1011	Fuel flow equalizer totalizer

GENERAL AVIATION MANUFACTURERS

Argentina	J	Cessna	Aircraft assembly
Brazil	J	Piper	Aircraft assembly and manufacture
	P	AVCO	Aircraft engine and engine parts
Canada	P	Fairchild, Bell, Cessna, Beech, Piper, Sikorsky	Aircraft engine
Mexico	P	Rockwell Int'l.	Aircraft parts
Poland	P	United Aircraft	Pratt & Whitney engine parts
United Kingdom	P	Grumman	Aircraft engine

* P - Procurement

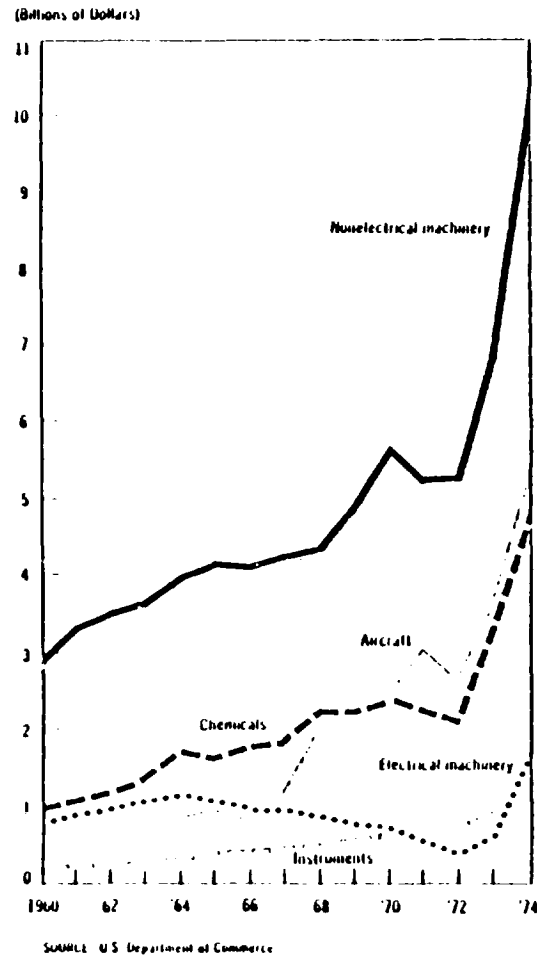
J - Joint Program

ARTICULATED POSITION OF AEROSPACE INDUSTRIES ASSOCIATION
REGARDING MEETING THE CHALLENGE OF
FOREIGN COMPETITION

CONTINUATION OF COMPARATIVE ADVANTAGE IN COMMERCIAL JET TRANSPORT
MARKET DEPENDENT UPON:

- A HEALTHY AND VIGOROUS U.S. DOMESTIC ECONOMY CAPABLE OF GENERATING SUFFICIENT NEW U.S. AIRLINE ORDERS TO MAINTAIN COST-COMPETITIVE PRICES
- THE LONG-TERM FINANCIAL STABILITY OF THE U.S. AEROSPACE INDUSTRY
- JOINT EFFORTS BY INDUSTRY AND GOVERNMENT TO MAINTAIN A SUPERIOR TECHNOLOGY BASE
- INDUSTRY'S ABILITY TO MAINTAIN A STRONG MARKETING AND POST-SALES SUPPORT PROGRAM
- AVAILABILITY OF SUITABLE LONG-TERM FINANCING FOR BOTH U.S. AND FOREIGN AIRLINES
- THE MAINTENANCE OF A RELATIVELY FREE AND OPEN WORLD TRADE ENVIRONMENT UNDER WHICH U.S. MANUFACTURERS HAVE OPERATED AND UNDER WHICH THEY HAVE EQUALITY OF MARKET OPPORTUNITY
- THE NATURE AND DEGREE OF INVOLVEMENT AND PARTICIPATION BY FOREIGN MANUFACTURERS IN U.S. PRODUCTION

Figure 1-20
U.S. Trade Balance in R&D-intensive
Manufactured Products, by Product
Group, 1960-74



SOURCE: SCIENCE INDICATORS 1974, NATIONAL SCIENCE BOARD, 1975

Figure 1-15a
U.S. Receipts and Payments for
Patents, Manufacturing Rights,
Licenses, Etc., 1960-74

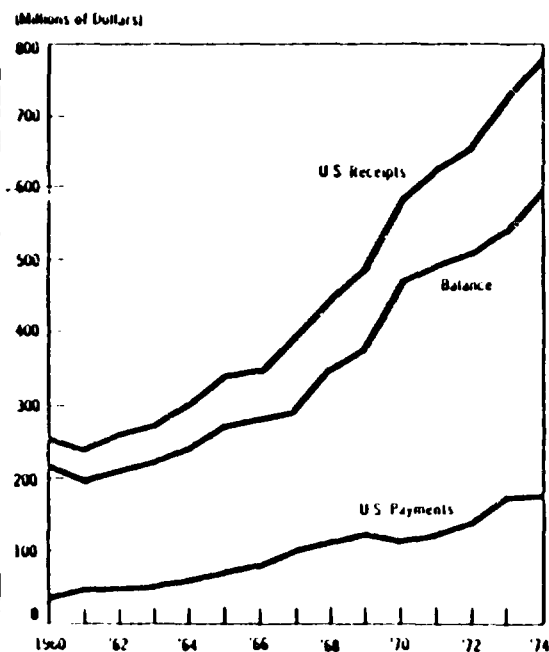
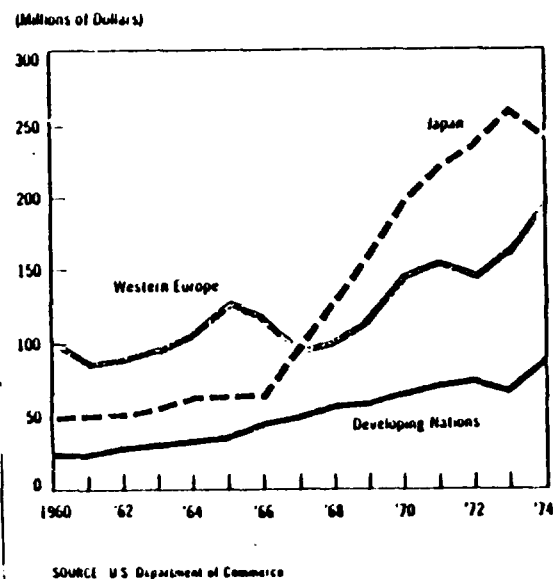


Figure 1-15b
U.S. Net Receipts for Patents,
Manufacturing Rights, Licenses, Etc.,
by Selected Countries, 1960-74



SOURCE: SCIENCE INDICATORS 1974, NATIONAL SCIENCE BOARD, 1975

Percent of total U.S. patents granted to foreign countries
by major product area, 1973

Product area	Percent	Product area	Percent	Product area	Percent
Drugs and medicines	44	Food and kindred products	33	Motor vehicles and other transportation equipment...	28
Aircraft and parts	39	Machinery, except electrical	30	Rubber and miscellaneous plastics products	28
Textile mill products	37	Electrical equipment, except communications ..	29	Stone, clay and glass products	27
Chemicals, except drugs	35	Professional and scientific instruments ...	29	Fabricated metal products	25
Primary metals	34	Communication equipment and electronic components ..	28	Petroleum refining and extraction	17

Figure 1-12
Major Technological Innovations,
by Selected Countries, 1953-73

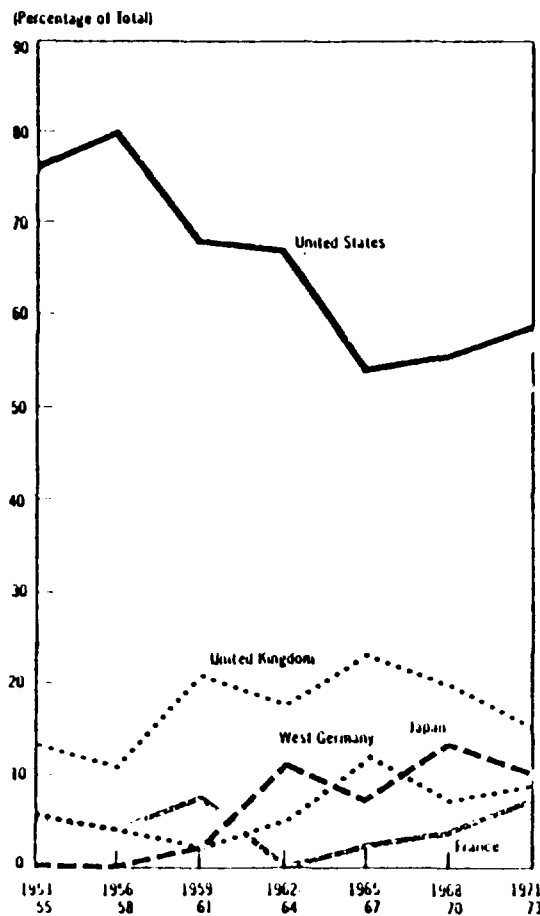
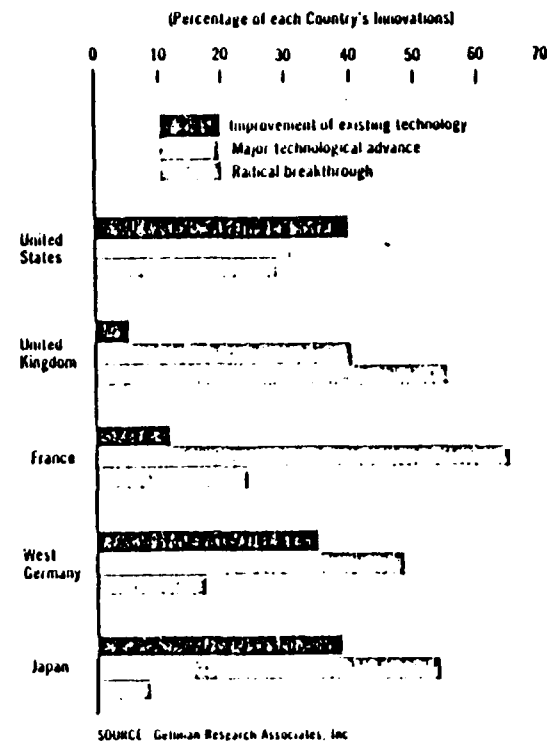


Figure 1-14
"Radicalness" of Innovations,
by Selected Countries, 1953-73



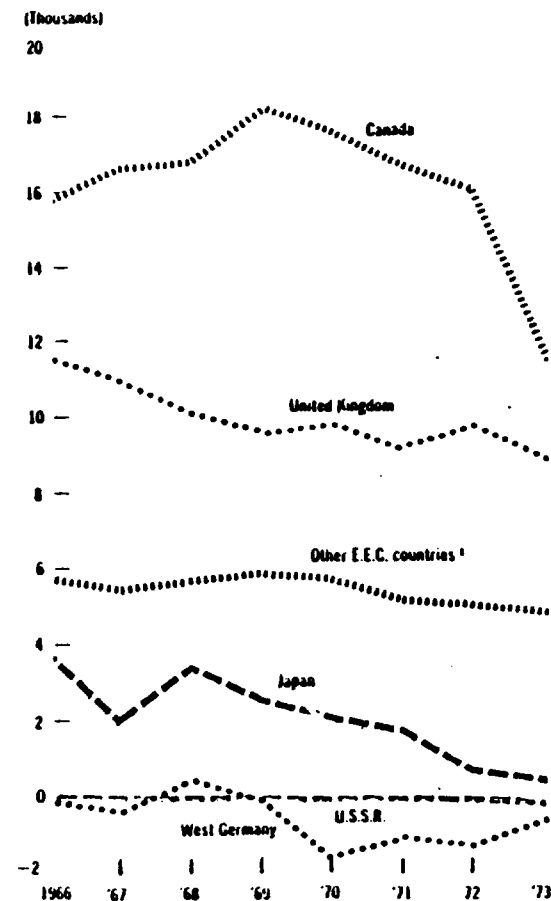
SOURCE: SCIENCE INDICATORS 1974,
NATIONAL SCIENCE BOARD, 1975

Figure 1-10
 Patents Granted to U.S. Nationals by
 Foreign Countries and to Foreign Nationals
 by the United States, 1966-73



* Including Canada, West Germany, Japan, United Kingdom, U.S.S.R., Belgium, Denmark, Ireland, Luxembourg, and the Netherlands.
 SOURCE: World Intellectual Property Organization

Figure 1-11
 U.S. Patent Balance with
 Selected Countries, 1966-73



* Other European Economic Community (E.E.C.) countries include Belgium, Denmark, Ireland, Luxembourg, and the Netherlands. Data are not available for Italy, and are not reliable for France for use in this study.
 SOURCE: World Intellectual Property Organization

PATENT BALANCE

SOURCE: SCIENCE INDICATORS 1974, NATIONAL SCIENCE BOARD, 1975

OAST FUNDING (FY-74)

	<u>NUMBER OF CONTRACTS</u>	<u>FUNDING</u>
UNITED AIRCRAFT CORP.	74	\$28,271,212
BOEING	75	17,188,328
GENERAL ELECTRIC	61	13,052,904
MCDONNELL DOUGLAS	32	10,560,499
LOCKHEED	26	4,078,355
LTV AEROSPACE	52	2,145,976
ROCKWELL INTERNATIONAL	19	1,331,624
GARRETT CORP.	9	639,647
GRUMMAN AEROSPACE	4	505,336
GENERAL DYNAMICS	10	488,351
LOCKHEED MISSILES AND SPACE	5	301,600
HUGHES AIRCRAFT	9	269,065

INTERESTING QUOTE

AVIATION WEEK
(2 FEBRUARY 1976)

THE U.S. CANNOT BE ACCUSED OF GIVING AWAY TECHNOLOGY IN
A COLLABORATIVE ARRANGEMENT IN EUROPE WHICH GAVE BIRTH TO THE:

- 0 JET ENGINE
- 0 SWEPT WING
- 0 JET TRANSPORT
- 0 SUPERSONIC TRANSPORT

let the environmental groups take their cause to court and let it have the final say regarding Coleman's administrative decision.

While Congress may be able to finesse the SST issue this time around, at least two other major legislative actions they may be unable to avoid. The most significant pending proposal is the Administration's regulatory reform proposal for the air transport industry. Last year, Sen. Edward M. Kennedy (D-Mass.), chairman of the Senate Judiciary Subcommittee on Administrative Practice and Procedure, held eight days of hearings on reform of the Civil Aeronautics Board. The Subcommittee's report, which came out at the end of

as it affects the Federal budget. Schultze said an underlying long-term inflation within the economy must be brought under control. His three chief means to attack long-term inflationary growth include deregulation of the transportation industry. The other two: hold down taxes and informal wage/price guidelines and income policies to limit increases.

The other major legislative action which could affect airline operations as well as user costs envisions separating the FAA from DOT—either as an independent Federal agency or as an independent government corporation. Congressman Barry M. Goldwater Jr. (R-Cal.) proposed to separate the FAA from

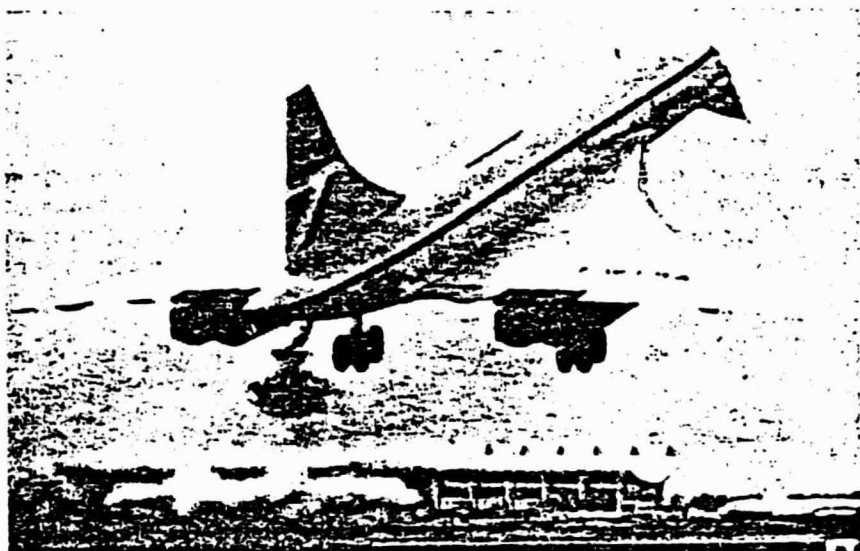
Technology Export: Success Draws Fire

Senate passage of the International Security Assistance and Arms Export Control Act moves Congress one step closer to being able virtually to veto any significant overseas arms sale. While the House has yet to act, the Senate's 60-to-30 vote suggests a strong sentiment in Congress to establish itself as the policy-making body to supervise foreign military sales. This adds still another dimension to the growing debate on the efficiency and desirability of high-technology trade by U.S. companies.

What would have been a routine foreign-aid bill authorizing \$3 million in budget outlays became the vehicle, through amendment in the foreign relations committee, for Senator Hubert Humphrey's arms-export proposals. The Senate-passed version of the bill would give both houses of Congress the veto for the first time over currently unregulated commercial sales. The bill's provisions would apply to all sales of \$25 million or more, or to sales less than \$25 million if the equipment carried an R&D cost of \$50 million or more, or total estimated procurement cost both recurring and non-recurring of \$200 million or more. In addition, the legislation requires that gifts or fees paid in connection with an overseas weapon sale would have to be reported to the State Department, which in turn would pass the information on to Congress.

Until recently, foreign military sales were expected to reach about \$10 billion for the fiscal year ending June 30. The latest estimates by Pentagon officials place the sales of arms support to foreign countries at \$8.2 billion, or less. Lt. Gen. Howard Fish, the Pentagon official who manages foreign-sales programs, estimates that sales next year may drop about \$1.4 billion, and level off in the \$6-7-billion range. Sales for FY74 hit \$10.3 billion, up from \$4.4 billion in FY73, and sales in FY75 reached \$9.5 billion.

While the aerospace industry generally supports the export of aerospace products, including military hardware, the issue of exporting aerospace technology generates some



On Concorde, a Congressional finesse, but on the Aviation Act of 1975, tough.

February, turned out to be very popular. The Subcommittee ran out of its supply of copies within a few days after it was released. The Kennedy report calls for the CAB to relax rate and entry procedures substantially while tightening its standards for granting antitrust immunity. It also calls for liberalized charter rules, increased consumer participation, and other changes in CAB regulatory procedures. Many of the suggestions are included in the Ford Administration's proposed Aviation Act of 1975. Hearings should begin on the Ford proposal shortly.

The regulatory reform proposals assume changes will lower fares. In recent testimony before the Senate Budget Committee, Brookings Institute economist Charles L. Schultze testified on the shape of the economy

DOT and return it to the independent status it held from 1958 to 1967. Congressman Teno Roncalio (D-Wy.) would create an independent government corporation as the overseer of the nation's airport and airways system. This corporation would be funded jointly, on an approximately equal basis, by user taxes and general tax revenues. Either proposal likely carries with it the reopening of the user-charge issue and the "fair share" applicable to the segments of the aviation community.

Add to these issues the still unresolved matter of jet-transport engine retrofit to meet new noise standards and the requirements for lower pollution by transport-category jet engines and the airline industry has plenty to think about in the months ahead. — Robert Hudock



Bucy: "We should not sell know-how or, worse, give it away faster than we can create it."

debates. One took place at the AIAA Annual Meeting session on exporting aerospace technology.

"Know-how is a basic resource that must be used wisely," says J. Fred Bucy, who just became president of Texas Instruments. "We should not sell know-how or, worse, give it away faster than we can create it." In his remarks at the Annual Meeting, Bucy differentiated between products and know-how.

The Texas Instruments executive recently headed a Defense Science Board task force on the export of technology affecting the U.S. defense posture. Although most U.S. companies would be reluctant to sell or give away their technological know-how to a domestic competitor, says Bucy, they seem more willing to do so in the international market. Bucy



Shields: Leave export of commercial technology to industry decisions.

notes that U.S. companies seem to be selling more know-how at a time when they are producing much less of it. The continued selling of technology means that what were once training partners soon will be trading competitors.

Roger Shields, assistant secretary of defense for international security affairs, completed the keynote portion of the program and echoed many of Bucy's thoughts. Shields said that "what we send abroad is the fruit of two centuries investment." Everyone seems in favor of exchanging technology for an adequate quid pro quo; but, asks Shields, "what is adequate?" Many U.S. companies, says Shields, look at the short run gain and do not worry about the long

times when the U.S. competitor will lose to a foreign competitor," predicts Shields. The Marines' purchase of the British Harrier and consideration of a German built tank for the U.S. Army are a few indications.

Shields would limit government controls only to military hardware and leave the export of commercial technology to industry decisions. Bucy, on the other hand, believes it is all right to export products but believes that U.S. industry should not export know-how. Bucy points to lost markets in ship building, steel, and black-and-white television because of the lack of sustained U.S. R&D.

The importance of technology goes beyond the interest of just the United



Clayman: "Exporting products is obviously what we all want."

run." Thus they often "bargain away the hard-learned and hard-earned technology."

Shields does see instances when technology transfer may be in the interests of U.S. companies and may be necessary for business; but he believes transfers should be truly a two-way street for technology transfer and commodities. He cited as an example the European purchase of the General Dynamics F-16 lightweight fighter. Shields believes that it is no longer true that a U.S. product can be sold abroad just because it is lower in price and higher in performance than its overseas competitors. In the case of the F-16, the sale would not have been made, he said, without joint production agreements which naturally result in a certain amount of technology transfer. Continued access to the two-way street means that "there will be

States and the other highly developed nations. Robert Basil, assistant director for United Nations programs in DDR&E, notes that countries often equate their development with technological progress. Basil finds a basic contradiction in the notion of trading high technology with U.S. allies. There is a need for trade and cooperation, yet there is also a need for the U.S. to maintain its underlying vitality; and this vitality comes in great measure from its technological progress. Basil believes that the intent should not be to control technology. He finds a fine line in exporting technology where a company must "sell it while it has value."

While government and industry have their own concerns, organized labor equates the export of know-how with the loss of U.S. jobs. "Multi-national corporations indulging in un-

Continued on page 41

2. *Minimum-wetted-area configuration.* Such a configuration would employ an even greater amount of tailored aeroelastic deformation than planned for HiMAT now. F-9 shows an example of the HiMAT core vehicle configured for this demonstration. This concept minimizes form and skin-friction drag.

3. *Variable-incidence wing.* This may be possible on small fighter aircraft. It allows independent shaping of the vertical path and pitch attitude degrees of freedom. This capability can be used for more accurate pointing and to quicken vehicle motion.

RPRV Problems

Since Dale Reed's article in 1974, DFRC and the rest of the industry has gained considerable experience in the operation of RPRVs.

The numbers from several high-technology RPRV programs reveal the main problem with the concept: they crash, on the average of one every 12-15 flights. This kind of record creates problems with the low-cost part of the concept.

The recovery of an RPRV presents another problem. Most of the small operational drones deploy a parachute and then a helicopter snares them in mid-air (Mid-Air Retrieval, MAR). This operation incurs a relatively high risk of loss of the picked-up vehicle. A parachute does, however allow very simple onboard systems.

This mid-air recovery often will not be possible for larger vehicles or vehicles which must resemble full-scale aircraft. The lack of a parachute then necessitates onboard redundancy or a means such as an onboard autopilot that will permit the vehicle to take care of itself in the event of loss of command signals. The complexity and cost of such an approach contravenes the "simple, cheap, expendable" concept that originally made RPRVs attractive. The vehicle may still cost less than a manned vehicle with a comparable technology suite. And it may be able to land horizontally most of the time, as tests to date indicate. But we still lack the data base to quantify the risk associated with horizontal landing.

The F-15 research vehicle has revealed one other main problem with RPRVs—they are expensive to operate. The F-15 RPRV program, for example, required about as many DFRC people, 30-40, as did the Lifting Body Programs. Total support on flight days, 80 people, was also comparable to the Lifting Body Program. These numbers indicate that, to be economically advantageous over the life of the program, the initial purchase price of an RPRV

must be significantly lower than that of a manned aircraft.

Three other RPRV problems often cited do not, based on our experience, present major problems:

1. RPRVs in general imply scale testing. The effect of scale on the validity of a technology demonstration must be considered. Once the designer departs from linear dimensions, he must compromise similitude in other areas. By proper consideration of scaling laws, however, he can usually maintain important parameters and obtain valid technical information.

2. The pilot control task for horizontal landing currently involves a very high workload. Numerous studies are planned at DFRC in the near future to investigate improvements to the control modes and crew station. We think relatively simple pilot-assist features can significantly improve the current situation.

3. Internal volume for flight-test instrumentation is restricted in scale RPRVs. By using miniature electronics and sizing some sensors to serve multiple purposes, instrumentation volume will likely be acceptable.

Future of RPRVs

Low cost and the ability to conduct high-risk tests chiefly make RPRV testing attractive. Examples of technical areas that surely expose a pilot to undue risk include flutter testing, flutter mode control through active-controls technology, and aircraft powered by laser energy beamed up from the ground. But not many technical test areas drive the pilot from the cockpit.

The more important incentive for remotely piloted testing appears to be cost savings. The ability to test at a smaller scale and therefore lower weight inherently lowers vehicle acquisition cost, as depicted in F-10. In addition, certain shortcuts can be taken in construction because of the ability to accept a higher risk and because there is no need for man-rating qualification tests and other factors of safety.

The pilot-vs.-RPRV decision must be made very carefully, however, on a case-by-case basis. For instance, in some situations a reduction in scale cannot be tolerated, and others demand the exercise of the man/machine interface. These cases will argue piloted flight research.

The engineer should view RPRV flight testing, we believe, as another tool that can supplement manned testing. To meet each flight-research need, he must weigh the costs and benefits, as always, and apply the most appropriate tool.

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bridled pursuit of corporate profits pose a direct threat to the economic health of the USA," warns I.W. Abel, president of the Industrial Union Department, AFL-CIO. "Loss of American jobs, the siphoning off of technological advantage, and the flight of American investment capital are now making themselves felt on a wider scale."

According to the AFL-CIO, the issues of exporting technology and the operations of multi-national corporations are closely linked. The AFL-CIO says that "...The multi-nationals have managed to put the United States in competition with itself—75% of this exported U.S. technology goes to foreign subsidiaries of U.S.-based firms." The trade union goes on, "Technology, itself, has become our fastest growing export. U.S. firms, mostly multi-nationals have been selling off America's technological advantage at an ever-increasing pace. U.S. receipts, in a form of licensing, royalty and management fees, from overseas technology buyers grew from \$650 million in 1960 to \$3.6 billion in 1974. U.S. firms now account for between 50 and 60% of the world's technology exports. The next highest exporter, Britain, provides 12%."

The export of technology by American industry is a short-sighted decision to gain quick profits, asserts Jacob Clayman, secretary-treasurer of the AFL-CIO's Industrial Union Department. "This is terribly unfortunate because either in the long run or the short run we lose the capacity to maintain our leadership in world production." Clayman says he and other American businessmen were raised on the premise that the great advantage the U.S. has in terms of both exports and production generally comes from our preeminence in technology. "And here we are willy-nilly shipping out the one advantage we have—our birthright, our shield, our edge in the competitive world. We are deeply concerned as to its consequences," Clayman told *AA* in an interview.

Clayman would rather be exporting U.S. products than technology. "Exporting products is obviously what we all want. A nation like ours cannot live without some kind of serious exportation of products."

Asked about the effect on the U.S.

Continued on page 49

to the Viking Orbiter vehicle class delivers 950 lb of thrust on bipropellants. 338 lb on monopropellant. It incorporates flight-qualified Mariner '73 catalytic reactors, a coaxial gas/liquid injector, and a coated columbium alloy thrust chamber cooled by radiation and a ducted film of hydrazine decomposition products. Vacuum specific impulse exceeds 304 sec at 40:1 expansion ratio with 12% film cooling.

An advanced 600/214-lb-thrust F_2/N_2H_4 version, which has the potential to deliver over 370 sec specific impulse, and could team up with space storable systems for planetary exploration, has reached the experimental engineering phase. Aerojet in 1972 demonstrated the basic feasibility of bimodal operation with fluorine and hydrazine. It has performance and durability verification tests underway. The engine incorporates Aerojet's radial inflow catalytic reactor and vaned oxidizer injector, and a reinforced-graphite lined thrust chamber overwrapped with ablative material.¹¹

A 100,000 lb-sec total impulse water electrolysis propulsion system under development by Marquardt for AFRPL offers significant advantages for Air Force satellite propulsion in the late 1970s and beyond. These advantages include 350 sec specific impulse compared to 230 sec for hydrazine monopropellant, and a 40% weight saving on a 3000-lb, seven-year-mission satellite. In addition, the engine will have a safe, non-toxic propellant exhaust, a clean water vapor plume, and consume a small amount of power.

The concept (F-13) combines inert propellant storage with high-energy propellant combustion by electrolyzing stored water as required to form gaseous hydrogen and oxygen which are burned. The gas generation rate can be matched to the mission and electrolysis carried out continuously. Continuous conversion reduces needed electrical power to below 20 w.

Two continuous tests of 14 and 19 weeks produced no signs of deterioration and showed that the system could last a seven-year mission. During those tests, a 5-lb-thrust engine produced 152,015 pulses totalling 4.16 hr of firing time, and a 0.1-lb-thrust engine produced 301,726 pulses totalling 10.07 hr of firing. At its completion in August 1974, the demonstration was judged successful in all aspects.

The future of liquid rocketry will grow from a fertile base of accomplishment. In just three decades, mankind has developed and refined the

technology for thrusting into space. He has built spacecraft that have extended his senses far out into the solar system. He has proven that man can survive and function for long periods in space.

Apollo and Skylab should prove difficult to top. The remainder of this century promises few comparable space spectacles, except, perhaps, the view of a huge Shuttle Orbiter standing on its tail prior to launch. Emphasis will shift to the systematic exploitation of space to expand our knowledge and improve conditions on Earth. At least through the end of this period we see liquid rockets playing a leading role in space propulsion.

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job market on the exportation of technology, Clayman responded this way: "We've not figured precisely how many jobs can be allocated to the shipment of technology or the allocation to the exportation of capital. But we estimate, because of multi-national corporation activities abroad, the U.S. has lost roughly 1.8-million jobs." Clayman believes that multi-nationals are "acting directly against the best interest of the U.S. economy and the U.S. people."

U.S. tax policy in good measure has prompted expansion of the multi-national corporation since the end of World War II. According to AFL-CIO estimate, the effective tax rate on total foreign sources of income of American corporations was about 5.1% in 1970. At the same time, the 100 largest U.S. corporations paid an effective domestic tax rate of about 26.9%.

Benefits available to multi-national corporations include the following:

- Special tax breaks for businesses operating in Latin America as Western Hemisphere trade corporations.
- Government-subsidized loans and credits for trade through the Export-Import Bank.
- Government underwriting of insurance against expropriation and other special risks to the overseas private-investment corporation.
- A 50% tax deferral for exporting firms (domestic international sales corporations).
- Foreign tax credit against U.S. taxes.
- Liberal tax-deferral provisions.

This rising expression of concern from the labor movement regarding the sophisticated aspects of the corporate structure is relatively new. In the past, the labor movement stuck to wages, job safety, hours, and other issues directly related to the working environment.

Labor's course of action against the multi-nationals and the export of technology "essentially has to be legislative in trying to procure the intervention of government by law," says Clayman. "We will be, I am sure, active in that field for years to come. It is hardly feasible to attempt to cure this kind of deep-rooted problem by simple labor/management negotiations; it of necessity requires the application of federal authority."

The labor movement generally sup-

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ported the proposed Burke-Hartke legislation, which had provisions controlling the export of technology. In supporting such legislation, Clayman says, "we would want some governmental controls because as it is now, without controls, American corporations are behaving in our judgment in an irresponsible fashion."

While the proposed Burke-Hartke legislation never got anywhere, Clayman finds a "rising support—a rising tide of concern and indeed resentment against the American multinational corporation." Clayman says that this view is also shared by other nations.

The traditional labor action of a strike remains a "potential weapon" to influence management not to ship production abroad and cause loss of jobs. "Whether it will be used I don't know," says Clayman; "we haven't used it so far, but it may indeed be a possibility for the future. If people get desperate enough about their jobs, they behave in that fashion. It isn't inconceivable."

Gus Weiss, senior staff member of the Administration's Council on International Economic Policy, believes the evidence does not support the position that the export of technological know-how has been detrimental to U.S. industry. He points to the balance-of-payments figures. Dr. Weiss notes that the high-technology industries show a \$28-billion surplus. Thus, he says, industry seems to be taking care of itself. Further, the technology is in the private sector and not the government sector; and government does not have direct control of all private technology. If government were to control all high-technology exporting there would be a need for a larger mechanism for analysis; and Weiss claims the management job would be "almost impossible." He suggests that the transfer of technology is all right so long as there is a strong R&D program to keep U.S. industry ahead.

Shields believes that neither industry nor government can prevent the transfer of technology in the long run, but only delay it. The Pentagon official suggests using this delay wisely—to create new U.S. technology. Thus the constant concern of aerospace and other industry leaders for the real level of R&D funding. — Robert Hudock ■

PLAN TO ATTEND



October 10-16, 1976

Anaheim, California

A BICENTENNIAL EVENT



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CONVENTION CENTER

AIAA will host the 27th Congress of the International Astronautical Federation (IAF) at the Anaheim Convention Center October 10-16. Dr. George E. Mueller is Chairman of the Host Committee for the Congress which has been designated a Bicentennial Event by the American Revolution Bicentennial Administration. ■ IAF

'76 will bring together international experts in the various fields of space technology for six days of technical meetings. The Congress will focus on the theme "A New Era of Space Transportation." The program is being established by an International Program Committee of the IAF, co-chaired by Professor André Jaumotte of Belgium and Professor G.G. Chernyi of the Soviet Union. The session topics will include Communications Satellites, Meteorology and Data Collection Satellites, Space Data Processing and Dissemination, Large Energy Systems in Space, Materials Processing in Space, Solar System Exploration, Space Medicine and Life Support, Apollo-Soyuz Results, Astrodynamics, Materials and Structures, Propulsion and others. In addition, a Colloquium of the International Institute of Space Law will review the Future of Space Law, Space Law and Energy, and the Relationship between Air and Space Law. (See Call For Papers, A&A December 1975 issue) The International Astronautical Federation, established in 1950, currently has 56 member Societies from 35 nations, representing more than 50,000 engineers and scientists. Leonard Jaffe, Deputy Associate Administrator of NASA's Office of Applications, is the 1976 President of the IAF. ■ Travel and hotel accommodation will be handled through Cardillo Travel Agencies, P.O. Box 24590 Los Angeles, California 90024. For additional information concerning the Congress, write or call AIAA, 1290 Avenue of the Americas, New York, N.Y. 10019. Tel: 212-581-4300.

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The thumbs on the trade scales

Analysts of international problems tend to forget that the U. S. is the only great industrial nation that still maintains an arms-length relation between business and government. American companies in many of our most essential industries are increasingly forced to compete, not just with their counterparts abroad, but with foreign national governments.

Under these conditions, industry in the U. S. is compelled to live—or die—by one set of rules while its adversaries around the world play the game by totally different rules that too often are divorced from the profit system and bear little or no relationship to costs of production. This situation raises a serious question as to whether any American company in a manufacturing industry can compete with government-owned, government-directed, or government-subsidized foreign firms and cartels that do not have to confront the ultimate discipline of the free market system.

The double standard that prevails in international trade makes our domestic market—the largest and most lucrative in the world—easy prey for foreign producers. By dumping, predatory pricing, and other practices that amount to the same, foreign-owned or subsidized companies have systematically and inexorably captured key markets. In the short run, these imports may appear to benefit the consumer, but in the longer run they leave our domestic companies unable to meet the needs of the economy. Then, when shortages develop, foreign suppliers can charge a significant premium for their products, as they did in 1973 and 1974.

Please do not misunderstand. I believe in free trade, and I am prepared to let the principle of comparative advantage determine who wins and who loses in the contest for markets. But I insist that free trade cannot exist without generally equal rules, with all parties competing on the basis of costs, technology, and productivity.

Lopsided. Tragically, this kind of free and fair trade rarely exists in the real world. This reality has been driven home to me by my corporate experience in recent years. As president of a company that is a primary producer of specialty steels, I have personally witnessed the destructive impact of a lopsided trading situation on this important American industry.

Specialty steels are absolutely essential to every major manufacturing industry in the U. S.—to all the energy industries, aerospace, communications, transportation, chemicals, food processing, and more. There is no economic activity in our society that does not require specialty steels. Yet in 1975 imports captured 60% of the domestic market for some specialty steel products and helped increase unemployment in the industry to levels as high as 40%. Shipments fell by more than 45% from 1974, exaggerating the already serious impact of the recession.

The gains of the foreign producers are not based on superior technology. Foreign specialty steel producers conceded at recent hearings before the International Trade Commission that American companies are at least their match in the realms of technology and productivity.

American companies are losing their markets because they cannot afford to match the discounts of up to 50% that foreign stainless steel and tool steel producers offer our American customers. We have found that no matter how many times we lower our prices, foreign producers will lower them further.

How can they afford to do it? Quite simply, most of them do not have to be concerned about profits. More than 70% of the world's steel capacity is now either government-owned or heavily subsidized. In Britain, the steel industry is almost entirely owned by the government, and in 1975 it lost more than \$500 million. In spite of this, the British government is providing or guaranteeing funds for a \$2.5 billion capital program for steel. One might ask whether any investor-owned company in the U. S. could ignore such losses and proceed with major expansion.

Japanese specialty steel producers, nearly all operating in 1975 at substantial losses, were encouraged to form "recession cartels" to control production and prices as well as cartels to control pricing of imported raw materials.

In addition, the Japanese National Bank has provided "impact loans" to specialty steel companies, which have enabled them to continue selling in the U. S. market at prices far below ours, even though U. S. prices for some products have been reduced by more than 20%.

In Sweden, as Prime Minister Olof Palme confirmed in his interview with *BUSINESS WEEK* in December, specialty steel producers receive government loans and grants to carry excessive inventories. The government will not permit them to lay off workers when demand falls. French producers receive government aid "to carry them through the present difficult period."

Trade policy. Our industry is not the only one facing this problem. Many others, equally vital, are being attacked in the same fashion. U. S. flag airlines, stockholder-owned, fight desperately to remain viable against government-owned foreign airlines, which need not concern themselves with profit. The Japanese computer industry is being heavily subsidized by its government so that it may compete more effectively worldwide. Many foreign auto producers have their governments as significant partners—in terms of ownership and even more important in terms of economic objectives. Throughout most of the world there is a pervasive attitude of cooperation between governments and industries.

It is clear that many nations of the world are



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R. P. Simmons is president of Allegheny Steel Corp. He is chairman of the committee that recommended the specialty steel tariff for repeal under the 1974 Trade Reform Act. The International Trade Commission ruled in favor of the tariff two weeks ago.

By R. P. Simmons

Continued



Government involvement in business is a way of exporting unemployment to this country

becoming more and more involved in economic areas which we view as the "private sector" in the U. S. As these nations give their backing to industries—they consider economically strategic, we here must rethink the broad question of trade policy. What is the meaning of free trade if the competing companies do not have to play by the same rules? Is competition really competition at all in such a game? Does the theoretically attractive concept of comparative advantage have relevance in an environment such as this?

America's superior technology still gives many of our industries an edge over foreign competition. However, as we continue to export our technology to the rest of the world this advantage is not as telling as it once was, and it will become less so in the years ahead. At some point—and the sooner the better in my opinion—we must face the fact that the growing foreign government involvement in business is a way of exporting their unemployment to the U. S.

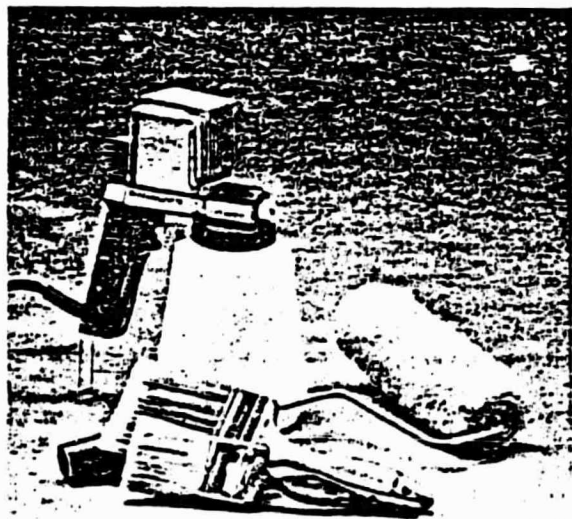
Congress sought to correct parts of the problem with the 1974 Trade Act, which was designed to provide American companies and workers with relief if they can prove that imports are a substantial cause of injury. But the broader issue I have raised remains to be examined. Can any U. S. company effectively com-

pete or be expected to compete with foreign-owned or foreign-subsidized companies that are used as instruments of national economic and political policy?

The new "world economics" being practiced worldwide clearly requires public debate and appropriate action.

Such action should start with an immediate investigation by an appropriate Congressional committee, recognizing that indeed there are "new dimensions" to the subject of international trade. If existing legislation permits, temporary quotas should be applied to products where producing companies are clearly victims of unfair competition. If new legislation is needed, the committee should recommend it.

Having taken these temporary measures, Congress should then begin examining the broad issues of world economic competition in an effort to find a longer-term solution. It has become increasingly clear that "black-hat-white-hat" logic no longer describes free trade and protectionism. All imports are not necessarily good, nor are they all bad. The label "protectionism" must not stop us from seeking ways to protect American companies, American jobs, and American self-interest from predatory practices that would be illegal under American law.



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**SHERWIN
Williams**

MULTILATERAL AERONAUTICAL DEVELOPMENTS

POSITION PAPER (DRAFT)

1 JUNE 1976

INTRODUCTION

This paper is a preliminary investigation of multilateral aeronautical developments and addresses the following areas:

- Trends
- The Nature of These Developments
- Possible Effects
- Conclusions
- Implications for U.S. Aeronautical R&T Policy.

TRENDS

Post World War II U.S. hegemony in commercial aircraft development and production is an unarguable fact with which we have become quite comfortable. The U.S. has produced nearly 80 percent of the free world's transports. Further, in the mid-seventies it has been estimated that with an aeronautics trade balance of about \$6 billion annually, aeronautics can be counted as one of the strongest elements in our foreign trade picture.

Historically, there are many well known reasons for this undoubted dominance, among them, World War II destruction of foreign plants (save British), Cold War military aircraft buildup and the attendant synergy with civil aviation, U.S. airframe company superior efficiency, superior financing, fine post-sales follow-up support, and recently, devaluations of the dollar.

There is good reason to believe that we are now at a crossroads for the U.S. commercial aircraft industry. At present the industry is in a holding pattern—current orders and sales are weak and new developments have been slowed. Nevertheless, the development of the next new generation of transports may not be long in coming, and this is the time for taking stock. In at least two fundamental areas there are significant changes in underlying parameters affecting U.S. commercial aircraft developers: (1) the civil-military/space interaction; (2) the increasing difficulty of financing development of new aircraft.

The civil-military interaction in the past has provided four important functions:

First, it provides funding through direct research and development (R&D) and indirect R&D expenditures on sales. Second, it provides stimulation to the technology by demanding new performance capabilities that are not currently available.... Since World War II there has been a clear flow of technology from military aircraft to long-range civil aircraft, and finally, to short-range civil aircraft.... Third, the military provides a test bed for new concepts that can be tested on a military aircraft rather than on a civilian aircraft (keeping civilian aircraft safe). Military security requirements also provide a pad on technology transfer that keeps certain advanced technology for the U.S. ^{1/}

^{1/} Booz Allen Applied Research, Inc., Competitive Factors in World Civil Aviation, 1972, p. 14.

In each of these areas a case can be made that this interaction is growing increasingly weak. Rockets and unmanned aircraft are in ascendance; cost plus fixed fee contracts were for a time largely abandoned; and in general military requirements are becoming less adaptable to civilian needs. The point at issue is not one of military subsidy of commercial development, but of the past strong and now weakening cross-fertilization and synergy between military and civil aircraft development.

The second increased difficulty for a U.S. aircraft manufacturer is the huge development cost for a new aircraft coupled with the extreme risk. The 747 cost nearly \$1 billion to develop while the A300B is estimated at \$982 million and the Concorde at \$3.1 billion.^{2/} This, coupled with spotty profitability records in the airframe industry for the current generation of aircraft, make private financing, unaided by government, a risky proposition. A related problem is the consistent U.S. record for multiple development of each generation of aircraft (707-DC8, L1011-DC10, 737-DC9, etc.) It has been demonstrated^{3/} that this unfortunate characteristic of U.S. plane-making is on balance wasteful, and that because of it (despite claims to the contrary),^{4/} the overall financial picture of U.S. commercial plane builders has never been good.

It is little wonder then, given this increasingly hostile environment, that commercial aircraft (and engine) companies have sought to share their risks with foreign producers and governments, and have called urgently for U.S. Government aid and regulation in new aircraft development. The extent to which foreign governments and producers have responded by offering to share development (and hence technology) with U.S. producers is investigated next.

THE NATURE OF MULTILATERAL DEVELOPMENTS

Commercial Aircraft

The future direction of these developments can be illustrated by examining some aspects of the current situation relative to the next commercial jet.

A short-to-medium run, 200 seat aircraft is contemplated, with emphasis on fuel and operating economy as well as low noise.^{5/} It is needed in perhaps 4-5 years to start replacing 707's, DC-8's and 717's. However,

^{2/} "The Challenge of Foreign Competition" Aerospace Industries Association, March 1976

^{3/} Sidney L. Carroll, An Economic Analysis of the Airframe Industry in the United States, Harvard University, unpublished dissertation, 1971.

^{4/} Donald Kyle, Diana Nagel, Robert Wood, The Economics of Air-Transport Manufacturing: Volume 1: Industry Analysis, NASA CR 137502, May 1974.

^{5/} Business Week, 12 April 1976.

U.S. manufacturers cannot get advance orders from U.S. airlines (as has been the case previously), and all manufacturers are seeking development and production partners overseas. Boeing's contender is the 7X7; McDonnell-Douglas' appears to be the DC-X-200. Overseas competitors are putting forth plans for a 200 seat A-300 and a stretched Mercure to accommodate 150 seats.

Selected aspects of Boeing's 7X7 program are cited in Table 1; other significant multilateral developments are noted in Table 2. Both tables illustrate a high degree of interaction between U.S. and foreign manufacturers.

Alternative Forms of Multilateral Interaction

Deals and arrangements with foreign companies can take numerous forms. Some of these forms are (1) subcontracts (e.g., for parts of an aircraft), (2) production licensing (complete transfer of production technology to another country), (3) joint development (as in the Concorde), (4) direct investment in foreign companies, and (5) direct sale of technology in the form of patents. Studies carried out or sponsored by the National Science Foundation have explored three categories, including (1) exports of products, (2) licensing of technology, and (3) foreign direct investment. Some of the results of these studies will be examined later in this paper.

POSSIBLE EFFECTS OF MULTILATERAL DEVELOPMENTS

General

No simple assessment of multilateral deals as "good" or "bad" could be accurate. There are, as in most instances, possible favorable and unfavorable aspects, depending upon the particulars of each. However, generally "good" points from the individual company standpoint and the government's standpoint and "bad" points from firm and industry standpoints are reviewed below.

A multilateral deal at its best can aid an aircraft company in at least the following ways: (1) Reduce and share the risk. With one or more partners the risk of loss for each is less, and the capital raised by each less. (2) Reduce front end cash flow. New transport programs (for example) take huge outlays at the beginning of the project before any revenues are generated. (3) Expand markets. For many reasons the multilateral endeavor may be the only way to participate in a foreign market. (4) Garner foreign technology. Foreign-developed advanced technology may only be available in this way. Possible favorable aspects at the national level are (1) expanded sales and positive contribution to the balance of payments, (2) maintenance of health and vigor of Free World foreign aircraft industry, and (3) in general, giving a piece of the action to friendly foreign governments is helpful to foreign policy.

Against these favorable points opponents often cite possible unfavorable aspects of the arrangements. Some of these are (1) losses to foreign companies of sales, jobs, and investment, (2) hemorrhaging of R&T

TABLE 1
SELECTED ASPECTS OF BOEING'S 7X7 PROGRAM

BOEING 7X7

- GREW OUT OF QSH PROJECT WITH AERITALIA (JOINT MANUFACTURING/
MARKETING AGREEMENT IN MAY 1971)
- CURRENT PROGRAM GIVES ITALIAN CONSORTIUM PRODUCTION
PARTICIPATION
- BOEING STATEMENT SAYS AERITALIA HAS 20% OF PROGRAM
- IF CFM 56 ENGINE SELECTED, FRENCH WILL HAVE 50% OF ENGINE
PROGRAM
- IF JT10D ENGINE SELECTED, GERMANY AND ITALY WILL PARTICIPATE
IN POWERPLANT DEVELOPMENT AND PRODUCTION
- JAPAN (MITSUBISHI CONSORTIUM) TRYING TO JOIN PROGRAM, AFTER
DROPPING OWN YX TRANSPORT PROGRAM
- COULD INVOLVE COOPERATIVE EFFORT ON NEW WING TO BE USED
BOTH ON 7X7 AND A-300B TRANSPORT
- TIMETABLE: FIRST 7X7 IN 1980-82 PERIOD; GENERALLY A
DERIVATIVE OF 727

SOURCE: DMS MARKET INTELLIGENCE REPORT, SEPTEMBER 1975
AVIATION WEEK, 16 FEBRUARY 1976

TABLE 2

OTHER SIGNIFICANT MULTILATERAL DEVELOPMENTS

DOUGLAS/DASSAULT-BREGUET

- 0 DOUGLAS BUILDS FUSELAGE BARREL EXTENSION AND PROVIDE TECHNICAL AND SALES SUPPORT FOR MERCURE 200
- 0 DASSAULT FUND DEVELOPMENT OF HIGH-ASPECT-RATIO WING FOR DC-X-200

DOUGLAS/AEROSPATIALE

- 0 COOPERATIVE VENTURE ON ADVANCED VERSIONS OF A-300B TRANSPORT

LOCKHEED/DASSAULT-BREGUET

- 0 NEW WING/POSSIBLE ENGINE CHANGE FOR MERCURE 200
- 0 POSSIBLE USE IN U.S. MARKETS

GE/SNECMA

- 0 CFM INTERNATIONAL, A JOINT COMPANY (FOUNDED IN 1974)
- 0 CFM 56 ENGINE
- 0 IDEAL FOR BAC 111, DC-9, MERCURE, 727, TRIDENT, A300, 707, DC-8-60
- 0 50/50 SPLIT, OVERALL PROGRAM MANAGEMENT AND SINGLE CUSTOMER INTERFACE FOR SALES AND SERVICES

P&W/ROLLS ROYCE, ETC.

- 0 CONSORTIUM TO MANUFACTURE JT10D-2 10 TON ENGINE
- 0 COMPETE WITH CFM56

to foreign companies (this can be a two-way street), and (3) negative balance of payments effects. Because of the multiple possible favorable and unfavorable effects, no blanket judgment can be given about whether this movement is overall "harmful" or "helpful."

Overview of Recent Testimony and Selected Earlier Studies

Testimony at the May, 1976 Congressional Hearings on the "Future of Aviation" gives the most recent industry views on multilateral agreements. Table 3 summarizes pertinent testimony which is available at this date. (To be updated as additional data becomes available.) This testimony is in general agreement with previous studies by the NSF and others. As a brief overview, Table 4 cites some of these results relative to industry in general whereas Table 5 lists results specific to the aviation industry.

CONCLUSIONS

From a review of the overall trends, current situation as well as a variety of study results, the following conclusions are shown:

- Multilateral aeronautical developments are inevitable based upon the current U.S. position and international trends.
- Direct transfer of R&T does occur via patent and licensing agreements for which payments are received.
- Most products involved in multilateral developments appear to be based upon "old" or well known R&T results.
- A limited number of products involved in these developments may be based upon "new" or recent R&T results.
- The potential for "inadvertent" transfer is limited since R&T results generally precede products by many years and most of the developments deal with products.
- However, some threats may exist in short lead time areas (e.g., manufacturing/production processes).
- R&T results in general are produced in a highly dynamic manner and represent a highly fungible commodity (e.g., people transfer, open literature, etc.).
- The strength of a U.S. company's bargaining position depends upon possession of advanced technology.

TABLE 3
RECENT CONGRESSIONAL TESTIMONY
(THE FUTURE OF AVIATION)

Mr. Frederick Bradley, VP, First National City Bank

- Financing Future R&D for advanced technology civil aircraft uncertain due to U.S. airline financial problems and due to difficulty and cost of obtaining long term financing. International joint ventures are providing one element of problem solution. (Chairman Milford doubted advisability of technology transfer abroad resulting from this solution.)

Mr. Gus Weiss, Staff Council on International Economic Policy, White House

- Major payoff for foreign joint ventures is capital availability to solve large program cash flow problems. Additionally, we obtain share of European market and acquire some European technology. G.E./Snecma agreement mated a French low pressure fan section with B-1 hot core to develop a low-noise, low pollution and more efficient engine (not possible without this agreement). Joint G.E./P&W effort not possible due to anti-trust laws and competitive posture (Subcommittee not satisfied that security arrangements on B-1 core would prevent technology transfer of this crucial military development).

Mr. Jack Hope, General Manager, CFP Program Dept., G.E.

- Motivation for foreign joint ventures is capital availability, reduction of financial risk, access to fastest growth markets and availability of additional R&D dollars. Engine life cycles are such that at release for production, engine is 6-10 years behind current technological capability (assuming continuing R&D progress). G.E./Snecma deal is pioneering a new path in U.S./European joint ventures. CFM-56 is a major new market (20-30K# Thrust) between 10K# and 50K# thrust engines. Product does not reveal schedule, cost, manufacturing techniques and other development secrets.

TABLE 4
RESULTS RELATIVE TO INDUSTRY IN GENERAL

STUDY RESULTS	SOURCES
Firms prefer exports to foreign direct investments and foreign direct investments to licensing	NSF, <u>The Effects of International Technology Transfers on U.S. Economy</u> , Colloquium in Washington, D.C. 17 November, 1973.
Firms tend to license their technology abroad more readily than in U.S.—in order to protect U.S. markets and obtain access to foreign markets	R.W. Wilson and M.J. Peck, <u>The Sale of Technology Through Licensing</u> , Yale University, PB 244-158, May 1975.
Royalty payments for an invention are well below the value of invention to license	Same as Above
Foreign direct investment makes a small contribution to international diffusion of technology—investment occurs in countries where competitive firms already exist	W.F. Finan, <u>The International Transfer of Semiconductor Technology Through U.S.—Based Firms</u> , NBER, 1975; A. Lake, <u>A Study of the Introduction of Innovations in the U.K. Economy</u> , NSF Grant, 1975.
Overseas activities by U.S. firms are beneficial — Increase exports and stimulate domestic employment — Provide means of acquiring foreign technology	NSF, <u>Technological Innovation and Federal Government Policy</u> , Jan 1976.
Available knowledge inadequate for assessing whether U.S. economy, on net, benefits from international technology transfer; many specific industries have benefited	G. Hufbauer and F. Adler; <u>Overseas Manufacturing Investment and the Balance of Payments</u> , Dept. Treasury, 1968; C. Freeman, <u>R&D in Electronic Capital Goods</u> , National Institute Economic Review, Vol. 34, Nov 1965.
Available evidence suggests that U.S. should maintain present policy — Except for national security considerations — No evidence, on net, that these have hurt U.S. economic welfare	NSF, <u>The Effects of International Technology Transfers on U.S. Economy</u> , Colloquium in Washington, D.C., 17 November 1973.

TABLE 5
RESULTS SPECIFIC TO THE AVIATION INDUSTRY

SOME SELECTED STUDY RESULTS

- EFFECT OF TRANSFERRING TECHNOLOGY WITH A LONG LEAD TIME TO PRODUCTION MUST BE VERY LOW
- OPEN LITERATURE ASSURES THAT BREAKTHROUGHS WIDELY DISSEMINATED
- TRANSFER OF LONG LEAD TIME BASIC/APPLIED RESEARCH IS PROBABLY BENEFICIAL
- TRANSFER OF MANUFACTURING EXPERTISE OR TECHNOLOGY WITH SHORT LEAD TIME TO PRODUCTION CAN HAVE EFFECT ON COMPETITIVE CAPABILITIES OF A FIRM
- LICENSING FEES CAN PROVIDE FUNDS IN U.S. FOR FURTHER DEVELOPMENT
 - E.G., MANUFACTURE OF ENGINES (GE-SNECMA)
 - TEND TO COUNTERBALANCE GAINS BY FOREIGN MANUFACTURER IN LEARNING ABOUT OUR MANUFACTURING TECHNOLOGY
- U.S. RECEIVES INFORMATION AND FUNDS WHEN TECHNOLOGY SHARED

Source: Booz-Allen Applied Research, Inc., Competitive Factors in World Civil Aviation, NASA CR-114447, August 1972.

SOME SELECTED STUDY RESULTS

- IF CURRENT TRENDS CONTINUE, U.S. WILL LOSE OUT IN MEDIUM AND SHORT HAUL AIRCRAFT MARKET
 - OUTRIGHT SUBSIDIES OF FOREIGN INDUSTRY
 - DECREASE IN TECHNOLOGY TRANSFER FROM MILITARY SECTOR IN U.S.
- FAVORABLE EUROPEAN POSITION NOT DUE TO INFUSIONS OF AMERICAN TECHNOLOGY
 - DEVELOPMENT TRENDS PROCEEDED IN PARALLEL WITH LITTLE CROSSOVER
 - AMERICAN POSITION PROBABLY BEEN MORE FAVORABLY AFFECTED BY ANY INTERCHANGE DUE TO GREATER ABILITY TO APPLY TECHNOLOGY
- MOST EFFECTIVE INTERCHANGE OF TECHNOLOGY ON INTERPERSONAL BASIS
 - LITTLE EVIDENCE OF ANY EFFECTS OF SUCH EXCHANGE IN AVIATION INDUSTRY
- U.S. SHOULD ADOPT POLICIES SUPPORTING R&D ON TECHNOLOGY INTENSIVE INDUSTRIES
- U.S. AVIATION INDUSTRY PROBABLY BENEFITTED FROM ANY EXCHANGE OF TECHNOLOGY RATHER THAN SUFFERED

Source: Forecasting International, Ltd., How Technology Transfer Affects the Competitive Position of the U.S. in the World Aviation Market, NASA CR-114448, 3 March 1972.

- Previous studies, in the main, appear to suggest:
 - Available knowledge is inadequate for a conclusive statement regarding the net benefits of these developments, and
 - The U.S. should maintain its current policy.

IMPLICATIONS FOR U.S. AERONAUTICAL R&T POLICY

Reiterating some of the reasons already stated herein, the current move to cooperative activities with foreign aviation firms is almost compelled by financial exigencies, government actions, and the profit motive. At any rate, continuation of the use of multilateral arrangements—good or bad—seems inevitable. The most salient point of the movement is that it reflects much more competition for U.S. firms. Foreign governments are increasingly funding R&T and production projects. The ability of U.S. firms to participate in joint arrangements and the strength of their position in bargaining for these deals depends vitally on their (U.S. firms) possession of the most advanced technology. NASA funding goes directly toward providing the type of advanced technological capabilities that are at the cutting edge of the formation of joint ventures. As competition from foreign entities grows, OAST-type research gains even greater importance for the competitive strength of U.S. aircraft firms.

Considering all of the facts, trends and study results to date, the following overall implications are drawn:

- No fundamental change should be made in current policy (long lead time R&T and excepting matters of national security).
- Careful examination may be needed of cases in which short lead time R&T is involved.
- The U.S. should face more directly its role as an exporter of R&T and the implications of that role in terms of obtaining, in some sense, a fair market value for that R&T and the need to provide for the continuous generation of R&T results.

OUTLOOK FOR AERONAUTICS - BEYOND THE 1980's

Prepared by:

Operations Research, Inc.

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OUTLOOK FOR AERONAUTICS—BEYOND THE 1980'S

The aeronautical industry today is maturing. Within our lifetimes, many of us have witnessed the industry change from one producing cloth covered aircraft (as recent as the early 1930's) to one producing modern, sophisticated aircraft. Two primary events accelerated the growth of the industry as we know it today. The first was the introduction of all-metal aircraft during the middle 1930's, a breakthrough which contributed to the birth and early development of the air carrier industry. The second, and perhaps more important event contributing to the rapid advance of aeronautical technology, was World War II. The research that had been ongoing for years by NACA and the aircraft industry provided a basis for the first war production models. However the requirements generated during the conduct of the war resulted in the development of higher performance aircraft and new techniques for producing them. The precarious situation of world peace during many years following the cessation of hostilities made it mandatory that our arsenal contain the latest in aeronautical weaponry and be responsive to ever changing needs. The situation still exists in which the United States must maintain leadership in aeronautics.

World War II brought the development of aircraft specifically for the commercial carriers to a virtual standstill. But shortly after the war, production began on four engine passenger aircraft. These aircraft were pressurized which made air travel more comfortable for the passengers and permitted the aircraft to operate at altitudes above much of the weather.

Pressurization of aircraft was a major milestone in the development of commercial carriers and the research carried on by NACA in the 1920's and 1930's contributed greatly to this advance.

The next major milestone in air carrier development was the introduction of turbine powered aircraft into scheduled service in 1958. The design of these aircraft was based upon the technologies developed by NACA and the Air Force in military applications—primarily air foil and powerplant development. The quality of the ride in turbine powered aircraft—low noise levels, little or no vibration and the speed of the journey—contributed greatly to the burgeoning demand for air travel, which was growing at an annual rate of 12 to 15 percent during the 1960's. The growth prompted the air carriers to order a new family of aircraft—the wide-bodies—in order to respond to the increasing demand in a more efficient manner. However, as these aircraft entered service, an unpredictable world wide recession began and resulted in the present over capacity situation among the airlines which, in turn, has had an adverse economic effect on the entire aircraft industry.

From 1958, when the first turbine powered aircraft were introduced into service, until now, the United States aircraft industry has produced more than 4,100 narrow body turbine aircraft and more than 600 wide body aircraft. A sad fact is that firm orders for new air carrier aircraft now number fewer than 200. Also, foreign competition is gradually penetrating the market, further aggravating the economic situation of the U.S. industry.

An interesting fact is that the major milestones in transport aircraft development have come at approximately 11 year intervals:

1935-38	All Metal Aircraft
1947	Pressurized Piston Aircraft
1958	Turbine Powered Aircraft
1969	Wide Bodied Aircraft.

It is no mere coincidence that major advances have occurred on this time table. History shows that the products of research require from 10 to 20 years to mature, from the original idea through the developmental and applied research stages to specific applications. The products of research

have been a catalyst to the manufacturing industry which made possible new vehicles in meeting the demand for air transportation.

Each of the major milestones in transport aircraft development was marked by two important factors—increased productivity and lower operating costs. Unless one or both of these two factors exist there is little reason for purchasing replacement aircraft. Successful research in the many fields of endeavor of the aircraft industry— aerodynamics, powerplants, materials, structures, hydraulics, avionics, controls and fuels— to name a few, have all contributed to the dramatic increases in productivity and lower operating costs of the present generation of aircraft.

For many years the development of new transport aircraft drew directly upon technology that was first used in military aircraft. However, about 20 years ago, the types of aircraft developed for military use began to require technology which had lesser application to civil aircraft. The result has been that applied research costs for new components in civil aircraft have been borne by the manufacturer which, in turn, has increased the costs of new aircraft.

During the early 1950's a transport aircraft cost about \$1,000,000. Today the fly-away cost of a wide-body is between \$25 and \$35 million. The economics of airline operations force such large capital outlays to be amortized over a longer period of time which greatly influences an airline's policy of aircraft replacement.

As previously indicated, successful new aircraft have shown greater productivity and lower operating costs than their predecessors making them commercially viable products. The latest entry into the air transport field, the supersonic Concorde, is selling speed of operation rather than economics. We shall all be observing this new aircraft with interest to understand the grounds for its success if indeed it becomes successful. The technology for supersonic aircraft is well understood in our industry as the Air Force and Navy have been supersonic for a number of years. Hopefully our research into the environmental and economic aspects of supersonic flight will be successful so that supersonic aircraft will become a part of our national scene.

To focus on the outlook for aeronautics in greater detail, a number of figures follow which illustrate many of the factors impacting on aeronautical development as well as concepts which are expected to be a major part of future developments.

Figure 1 depicts the general pattern of aviation development over the past 30 years and the trends expected for the next 30 in terms of aircraft productivity and Research and Development investment. The increasing research and technology development investment between 1940 and 1955 brought about the introduction of the jet engine, the swept wing and the wide-body structure and as a consequence, major improvements in productivity. The pattern of increasing research and development investment changed in the late 1950's and 1960's, as shown in the figure, and relatively few new developments can be expected for the period 1970-1985.

The chart reflects the fact that the halcyon days of aircraft industry growth are about over. At least the rate of growth will be slowed for a period of time, reflecting the typical pattern of a maturing industry. In this type of industry, advances in productivity are going to come harder and cost more.

In the early days, the demand for air transportation first drew from the railroads, buses and steamships. The new forces at work in stimulating other forms of intercity travel put more pressure on civil aviation to be cost-effective and competitive.

Since 1938 the certificated airlines have operating under regulations which fixed both route structure and fares. Certain segments of the aviation community now believe that these regulations inhibit the growth of air transportation by stifling free enterprise. Suggested modifications to the regulations are contained in proposed legislation recently submitted to the Congress by the Department of Transportation. If changes in the regulations do come about and do result in greater demand, the results probably will take a considerable period of time to be felt by the manufacturing industry.

As pointed out previously, modern sophisticated equipment requires great investment and needs many years of operation to recoup. Heretofore, the airlines could look to the used airplane market in their re-equipment

planning. However, the used aircraft market has slowed considerably, forcing airlines to other considerations for their aircraft replacement programs.

In sum, the tendency is toward a slower development process. The immediate outlook seems to be fewer new aircraft and a longer time between new models.

The operators must decide on the basis of economics and not performance in their assessment of any new equipment programs.

Some of the above remarks have reflected the gloom that hangs over the aeronautical industry at present. However there are positive forces at work that can and will have a beneficial effect upon the industry. Or, in other words, so much for the bad news; now for the good!

The first is people. The production of large aircraft may be down but the production of people continues apace. Recent figures have put the population of the world at three billion with this number expected to double by the year 2000. The year 2000 is not really too far off. And with these increases in population will come increases in the demand for air transportation.

The passenger demand for air transportation is presently growing at the rate of about seven percent annually. Although this is only about half of the growth rate experienced during the 1960's, it will, nevertheless, double the present demand for air transportation by 1986 if growth continues at the present rate.

Supplying the needs of the growing population will increase the demand for transportation of all kinds. Air has a definite role in the future for transporting cargo. Indeed the flexibility that air brings to the transportation of goods can make it a much more dominant factor in the distribution system than it enjoys today. Many developing countries are using air transport successfully in solving their internal distribution problems while progress is being made in the time consuming development of surface transportation systems.

One relatively small U.S. manufactured cargo aircraft is contributing significantly to solving developing country transportation problems. Originally produced for the U.S. Air Force beginning in 1955, the Lockheed C-130 and its commercial derivatives, the L-100 series, are still being produced. Over 400 of these aircraft have been delivered to foreign countries where many of them are used primarily for civil distribution problems.

The use of aircraft for cargo transportation has been growing steadily for 25 years and is predicted to continue to grow. In 1950, the airfreight volume generated by U.S. carriers was about 0.3 billion ton miles. In 1974 the volume was 6.0 billion ton miles—a 20 fold increase.

A number of controlling factors in aviation are presented in Figure 2 and illustrated in greater detail in Figures 3 through 8. Increasing costs will be reflected in higher fares (Figure 3); modest growth will absorb the remaining capacity in the airways system and at existing airports (Figure 4); and competition from government-sponsored foreign aircraft industries will become more vigorous (Figure 5). In military aviation, the U.S. can expect further reductions in access to overseas refueling sites (Figure 6) and fewer foreign logistics and staging areas (Figure 7). Moreover, military weapons will increase in cost necessitating the development of fewer but more effective weapons systems (Figure 8).

Primary directions in aeronautical development that are expected to result from the controlling factors noted above are summarized in Figure 9. Directions for both civil and military aviation are listed. Progress in these directions will depend critically on the extent to which the necessary technology investments are made.

The future directions of aeronautical development draw attention to the potential opportunities afforded by air transportation, both domestically and internationally. These new opportunities are shown in Figure 10 and the characteristics of the aviation system that would result are summarized in Figure 11.

Against this background of controlling factors, technology directions and potential opportunities, there are a number of ongoing programs which NASA and industry are jointly sponsoring.

The first such ongoing program is the Aircraft Energy Efficiency Program. Efforts under this program include research to develop more energy efficient transports, more energy efficient engines through improved engine components, and, in general, more energy efficient propulsion techniques. In addition, research under this program is aimed at greatly reducing aircraft drag.

Research aimed at developing more energy efficient transports (Figure 12) seeks to improve aerodynamic concepts and the development and incorporation of active controls technology in new aircraft designs. The first phase of this program will intensify NASA efforts on the application of advanced aerodynamics to the design of a transport with higher aspect ratio and lower wing sweep and corresponding improvement in lift-to-drag ratio and fuel consumption. The advanced aerodynamic design will be carefully integrated with the propulsion system to minimize installation penalties. Investigations will also be made on the use of active controls for relaxing design constraints for static stability margins and reducing the tail size, as well as for alleviating gust and maneuver loads. An important aspect of this activity will be to develop methods for improving the reliability of flight control systems. These aerodynamic improvements could save an estimated 10-15 percent in fuel usage compared to today's wide-body transports. The use of active controls could increase that by an additional 5 percent.

In FY 1977, detailed design and analysis studies will be performed with the engine manufacturers to select those component improvements which are attractive from both a technical and economic viewpoint. Development of the selected components in both component tests and engine tests will begin. These components, such as abradable seals, active clearance controls, and combustion liners, shown in Figure 13, will have a high probability of being incorporated into future production of current engines such as the JT8D, JT9D, and CF6.

For the longer term, work will begin on the first phase of a program directed at providing the technology base for future aircraft engine designs which would be significantly more efficient than today's engines.

Studies completed this past year have shown that the incorporation of advanced components into future engine designs could result in a 10 to 30 percent improvement in specific fuel consumption. This fiscal year, NASA will initiate the intensive development of fan, compressor, combustor, and turbine components required for an advanced turbofan engine such as the one shown in Figure 14. These developments will provide the basis for proceeding to a second phase of an intensive engine-directed component development effort which could lead to a complete engine ground-test demonstration in the early 1980's.

Drag reduction programs include research into laminar flow control techniques which seek to maintain smooth or laminar flow over the wings and tail.

As shown in Figure 15, the potential fuel savings from laminar flow control (20 to 40 percent) are impressive, depending on the extent of applications and on the airplane design range. It is important to recognize, however, that this high payoff technology will not be incorporated in new aircraft designs until the possibility of developing a practical, maintainable boundary-layer suction system has been thoroughly demonstrated.

Early experiments with the USAF X-21A airplane (Figure 16) in the mid 1960's demonstrated that laminar flow could be consistently maintained, although at that time the pumping and hardware systems were not developed to a cost-effective stage.

Recent developments in lightweight structures and in advanced pumping systems show promise of attaining economically viable systems that are reliable and maintainable. In FY 1977, efforts will concentrate on the evaluation of various suction surfaces and structural design concepts to select the most promising candidates, and on the continued development of analysis methods necessary for optimizing laminar-flow aircraft designs.

Earlier reference was made to the future importance of supersonic aircraft. In supersonic flight, civil and military aircraft of the future will have some characteristics and many problems in common. Both classes require increased aerodynamic efficiency to maximize range and payload and minimize fuel consumption, more efficient propulsion systems, new materials to minimize structural weight, and improved structural design approaches and control systems. There are differences due to the environmental constraints on civil aircraft and the maneuvering capability required for fighter aircraft which impact for the selection of engine cycles, aerodynamic configuration and structural design. The technology required to develop a successful supersonic cruise vehicle is also dependent upon the cruise speed selected.

One of the primary measures of a transportation system's merit is the product of the payload and the distance it is carried in a given time interval. On the basis of this productivity criterion alone, supersonic transportation appears inevitable, whether or not the first-generation European entries prove economically successful. When development of an American supersonic transport is undertaken, it will have to offer large advantages over the most advanced subsonic jets, and over the initial and improved versions of the Concorde and the TU-144, in order to compete successfully on the world market. It will also have to overcome the environmental concerns which figured in cancellation of the original SST prototype program. It is believed that the supersonic cruise aircraft research now in progress could lead to a second-generation SST with at least a 100 percent increase in payload capability, a 25-30 percent increase in range, and a 25 percent increase in speed relative to the Concorde, with noise levels well below current federal regulations, and with objectionable engine emissions reduced by 90-95 percent relative to present-day engines.

The optimistic predictions are based on several new conceptual approaches which were not far enough along when the first-generation designs were being solidified. The new approaches still require considerable work to assure technology readiness. They include, for example, the "blended" configuration, shown in Figures 17 and 18, and the arrow wing planform shown in Figure 18, which offer considerable increases in aerodynamic efficiency compared with the more familiar delta shapes. Interest

in these refined aerodynamic shapes has been spurred by new structural concepts which have increased our confidence that the configurations can be designed for practical manufacture. The arrow wing, incidentally, has the additional advantage of spreading the lift over a longer length and thereby reducing sonic boom effects. The advanced supersonic design concepts also include the use of propulsive lift to enhance the wing lift for low-speed performance improvement and noise reduction and the use of a totally new variable or multi-cycle engine. The multi-cycle engine, which is still in the early stage and requires extensive technical development, is an essential new feature. The concept is somewhat similar to that of the variable-sweep wings used on supersonic combat aircraft. Here the internal engine geometry, rather than the wing geometry, is altered to vary the engine airflow as a function of flight speed. Operating in a sense as a gear shift, the variable cycle permits effective low-noise operation for takeoff and landing while still maintaining high efficiency for supersonic cruise. An additional feature of this engine is the improved specific fuel consumption as compared to after-burning turbojets (Figure 19). Lastly, the new configurations will gain additional performance through the weight savings achieved by use of the active controls concept. In the supersonic applications, the active controls may include vectored thrust as well as aerodynamic control surfaces.

To accomplish the SST noise level and engine emission reductions mentioned previously, significant technological advances are required. However, as indicated in Figures 20 and 21, technological developments are underway which are expected to result in significant noise level and emission reductions and which hold promise for even further improvements.

With a look even further into the future but with the roots of growth even now established, a brief look at a hypersonic aircraft is presented next.

The hypersonic transport can be envisioned as a follow-on or perhaps even an alternative to the second-generation supersonic flight. Operating at three times the speed of Concorde—or about eight times the speed of today's jet transports—and capable of very long ranges, the hypersonic

transport could be of interest in an era of increased East-West and African trade. Hypersonic transports would operate at extremely high altitudes and use liquid hydrogen fuel. With respect to environmental considerations, the altitude increase significantly reduces sonic boom effects on the ground and, although the hydrogen fuel may present a water vapor problem, it contains no hydrocarbon pollutants.

At first glance, as can be seen in Figures 22 and 23, the hypersonic airplane looks quite similar to a supersonic vehicle. Actually, there are some major differences which account both for the spectacular performance and the technological risk.

The airplane is powered not by a conventional turbojet or turbofan engine, but by a supersonic-combustion ramjet integrated into the structure (Figure 24). Because of the very high flight speeds, the structure must be cooled by circulating liquid through tubes embedded in the external skin, depending on the large cooling capacity of the liquid hydrogen to remove the heat. Hypersonic research engine tests have been conducted successfully in the laboratory; a possible flight research program to further the development of the hypersonic cruise flight concepts is currently being considered jointly by NASA and the Air Force.

To accommodate long-range supersonic and hypersonic transport aircraft, new concepts in air terminal facilities will be required. An artist's concept of an international supersonic/hypersonic air terminal is depicted in Figure 25. The terminal is located offshore on a man-made island-lagoon built up from the sea floor on the continental shelf. At such locations, perhaps 20 to 30 miles offshore, noise would be of little concern, and should the use of hydrogen fuel become necessary its on-site production from sea water through dedicated nuclear energy plants would simplify the problem of fuel distribution. A world-wide intercontinental air system could be implemented with as few as 20 of these airports.

In the regime of "Low Speed Flight," which includes Short Takeoff and Landing (STOL) and Vertical Takeoff and Landing (VTOL) aircraft, NASA, together with agencies of the Department of Defense, has many ongoing research programs. Research and technology base activities planned for FY 1977 for STOL aircraft will be focused on improving low speed lift and cruise performance while, at the same time, reducing noise.

Studies and experiments to find means of reducing noise are a continuing effort. Wind tunnel models of an upper surface blowing configuration have been developed. These models will be used to test various noise absorbing materials designed to reduce the noise of the scrubbing action of jet exhaust.

A number of aircraft are being used to study aerodynamic characteristics during flight in close proximity to the ground, and in continuing study and documentation of flying and handling qualities. In addition, a lift augmentation scheme installed on the C-8 Buffalo is under extensive investigation. The flap system, under this concept, would be retracted during cruise to form an efficient airfoil section. There could also be advantages in operating the augmentor in a cruise mode as well. The need to completely retract the flaps could be eliminated permitting a simpler and lighter weight wing/flap structure, and valving for the ejector air would be eliminated since the ejector would remain operative during cruise to produce thrust. Following further study and analysis of the concept, it is planned to evaluate a wing model in a wind tunnel in FY 1977.

It is from work such as this that the powered-lift concepts evolved which are now being used on the Air Force's Advanced Medium STOL transports (AMST's). The Boeing YC-14, shown in Figure 26, is configured with upper wing surface blowing and is scheduled for first flight in mid-1976. The first flight of the McDonnell-Douglas YC-15 (Figure 27) occurred in August 1975. This aircraft employs externally blown flaps.

Using the technology base generated within NASA, coupled with the Air Force activities, NASA has undertaken a program entitled Quiet Short-Haul Research Aircraft (QSRA). The QSRA Program was initiated in FY 1974, and a contract will be awarded in early 1976 for the final design and fabrication of the research aircraft.

The research aircraft, shown in Figure 28, will be a surplus C-8A Buffalo airframe provided with new wings and four surplus AVCO-Lycoming jet engines for propulsion and lift augmentation. The hybrid Upper Surface Blowing (USB) propulsive-lift concept is designed to achieve high-lift efficiency with low noise. The exhaust flow from the four turbofan engines is directed across the upper surface of the wing to provide lift augmentation.

In addition, bleed airflow from the engines is directed through the wing to provide boundary layer control in selected locations to enhance the lift performance and control at low speed and under one-engine-out conditions. The over-the-wing location of the engines provides flyover noise shielding in addition to noise reduction through acoustic treatment of the engine installation. Analyses and wind-tunnel tests indicate that the hybrid configuration will provide a 50 percent increase in lift for about the same thrust to weight ratio as the simpler upper surface blowing or external blowing systems.

The STOL aircraft could become an important part of the world aviation scene. As large metropolitan airports become more congested because of increasing demand, satellite airports may become necessary. The scarcity of available land for airport citing will require vehicles having STOL characteristics. The STOL aircraft of the future could provide for both passenger and cargo traffic in the United States as well as in many other nations.

In addition to the development of STOL technology, NASA has many ongoing programs in the development of VTOL aircraft. Rotorcraft, which are typified by the helicopter, provided a unique capability. They can hover more efficiently than vehicles using any other means of powered lift. To attain this unique capability, other performance capabilities, such as cruise speed, are compromised. Yet the value of the helicopter's operational capability is sufficient to make the helicopter irreplaceable.

Problems related to the deficiencies of helicopters are being attacked in a continuing research program which includes aerodynamics, structures, materials, and new rotor concepts. Analytical, wind tunnel, rotor tower, and flight simulation techniques are employed as are flight tests, which are an essential part of rotorcraft research due to limitations in ground-based facilities.

Much of NASA's research effort directed to rotorcraft is conducted in conjunction with the U.S. Army which is the world's leading user of helicopters. Much of the vehicle technology developed in the joint NASA/Army research activities is equally applicable to civil vehicles. However,

in response to the increased utilization and predictions of dramatic growth in the civil helicopter industry, NASA plans to define the problems and assess the need for more research emphasis on civil helicopters. NASA's goal is to ensure that the technology is available on a timely basis to maintain U.S. leadership in both military and civil vehicles.

In another direction of VTOL aircraft development the Navy has a unique requirement. In recent years the Navy has joined NASA to augment research efforts on the lift/cruise fan. Two lift/cruise-fan configurations are shown in Figure 29. In both of these configurations, a lift-fan is mounted in the nose of the aircraft for trim and pitch control in hover and low-speed flight. Such a fan can be powered by hot gases ducted from a remote engine to drive a tip-turbine at the outer edge of the fan, as illustrated by the configuration sketched in the lower right of the figure, or the fan can be driven by shafting from a remote engine, as illustrated by the sketch in the upper left of the figure. In cruise flight, the lift-fan in the nose is stopped and covered by movable louvers that are open during takeoff and landing. The cruise fans shown mounted at the wing/fuselage juncture provide lift during takeoff and landing by deflecting the jet exhaust downward with nozzles, as shown in the sketch in the lower right, or by tilting the fan units to a vertical position, as would be the case for the configuration shown in the upper left. During cruise flight the jet is exhausted rearward. A number of typical lift-fan aircraft are depicted in Figure 30.

Commercial uses of VTOL aircraft could contribute to the revitalization of inner urban areas. The aircraft depicted in Figure 31 is an advanced rotorcraft capable of quiet vertical takeoff and landing from sites close to or within urban centers. Large rotors would provide efficient lift in vertical flight and when reoriented would act as large propellers in horizontal flight. Other VTOL concepts, including those mentioned above which utilize large fans in place of rotors, are equally promising and may prove more efficient over longer routes. VTOL aircraft could provide both intraurban and interurban passenger service and serve as versatile high speed links to major hub airports.

It was stated earlier that the shipment of cargo is expected to have considerable impact on the future of aeronautics. Figure 32 illustrates the historical growth of air cargo and shows the results of recent forecasts of potential growth. The history and forecasts of demand in terms of revenue ton miles indicate that the current market demand was preceded by an annual growth rate of approximately 13.5 percent since 1960. This market has been characterized by high value unplanned and perishable goods which could maintain an 11 percent growth rate in the future.

In 1970, studies showed that the "threshold" of product value constituting air eligibility was approximately \$1 per pound based on the costs of air transportation at that time. If the costs of air transportation are reduced by moderate decreases in the cost of ground operations and by more efficient aircraft designs, or both, attractive new markets exist. If reduced air transportation costs allowed the air eligible product value threshold to be lowered 25 percent, then an impressive array of major consumer items would be attractive for air cargo including such items as refrigerators, washers, and automobiles. The lower threshold would make possible the use of air for planned air shipment and would result in the new market objective of 16 percent annual growth shown as the top curve of Figure 32.

Figure 33 shows the decreases in the cost of producing air transportation through increased productivity by comparing three different aircraft. Also shown are the costs of competing transportation. The "stretched" DC-8's achieved a 10 percent decrease in operating cost over the Boeing 707 but economies of scale are readily apparent in the wide-body Boeing 747 cost figure. New designs promise a much lower cost. Indeed such low costs per ton mile should permit a sizable penetration into the market now dominated by surface vehicles.

Advanced designs have the potential for approximately two times the efficiency and payload capability of current wide-body transports. The large cargo aircraft may carry most of its load and its fuel in the wing rather than in the body as shown in Figure 34. This flexibility in load distribution is one of the benefits of large size, and permits major savings in structural weight since the distributed load balances the aerodynamic lift forces on the wing. The result is a potential payload increase on the order of 50 percent,

with a corresponding decrease in operating cost and fuel per ton mile. Studies of large cargo aircraft will be continued in FY 1977 to guide NASA research efforts in concept definition and to determine the application of advanced technologies, such as composite structures, active control landing and flight systems, propulsive lift, and thick airfoil sections to these configurations.

Figure 35 shows a comparison of the fuel efficiency of current commercial aircraft and the prediction for an advanced design such as the span-loaded flying wing concept. As can be seen the economics of such a vehicle promise viability.

However such an aircraft would require many changes in the present air cargo support system. Conceptual changes are shown in Figures 36 and 37.

Figure 36 shows a loading dock that would be required for efficient loading of a spanwise loaded freighter.

Figure 37 is an illustration of a future air cargo terminal. Clearly many changes would have to be made in cargo handling methods but when one examines the innovations that have been made by surface transportation in the handling of containers the adaption to air would not be difficult.

The potential of large cargo aircraft has also attracted the attention of foreign aircraft manufacturers. Other nations are conducting studies and investigations of large cargo aircraft concepts. Two examples of foreign developments are depicted in Figure 38.

The development of large cargo aircraft may well spearhead the development of integrated air cargo systems. The intermodal cargo terminal depicted in Figure 39 is an example of such a system. Air and surface transportation are integrated with a modern warehousing complex. Dedicated cargo aircraft, weighing 1,000 tons or more and operating between intermodal cargo points would permit the rapid distribution of materials and products between centers of production and centers of consumption, and greater flexibility in the location of processing and manufacturing industries. It is conceivable also that even larger amphibious cargo craft, fueled either by hydrogen or nuclear reactors, or modern lighter-than-air ships could operate from the offshore terminal discussed earlier, as well as from cargo ships at sea. An artist's conception of a modern lighter-than-air ship is depicted in Figure 40.

A new topic, and one that is uppermost in the minds of many researchers, is concerned with future energy sources for aircraft. Predictions of fossil fuel exhaustion after the turn of the century are commonplace. Two alternate sources of energy for powering aircraft have been under investigation for some time. The first, nuclear energy, has been investigated through many preliminary design configurations in industry as well as agencies of the government. The shielding problems result in aircraft of great weight and, consequently, size which would be difficult to justify in commercial applications. And perhaps more important and of much social significance would be the catastrophic crash considerations. It is not as yet foreseen how these problems would be solved.

The second potentially usable energy sources are cryogenic fuels. The use of liquid hydrogen, or possibly liquid methane, as an alternate fuel is being considered for both subsonic and supersonic aircraft, depicted in Figures 41 and 42 respectively. Depending on the cost and energy required to produce them, the liquified gases could be of interest as a means of reducing dependence on petroleum and other fossil fuel sources. In their application to aircraft, substantial technical effort is required to assure adequate thermal protection and strength in lightweight engine design. However, the cryogenic fuel concepts appear entirely feasible. NASA experience with hydrogen fuel in aircraft goes back almost two decades, to 1957, when flight experiments were conducted with a B-57 airplane modified so as to permit fueling of one of the engines with hydrogen in flight. The results of that early experiment were entirely favorable. More recent experience is the NASA space program. Over 600,000,000 gallons of liquid hydrogen were obtained, transported, loaded and consumed without a single accident attributable to the use of that fuel. Complete liquid hydrogen fuel systems were developed including pumps, valves, conduits, fuel injectors and leak detectors. However, formidable technology problems lie in the system support areas of economical production, liquification, distribution, storage and handling on a world wide basis.

Large more productive aircraft, both passenger and cargo, will certainly influence our foreign trade. As our relations become more stabilized with the nations on the other side of the Pacific Ocean, vast markets could open. New transpacific markets as well as new marketing areas in the developing countries of Africa involve great distances to be flown. Speed—increased speed over present day aircraft—may be an important element in successful future air transportation. Research is pointing the way to increased speed combined with the necessary reduction in operating costs.

Many countries of the world do not have the extensive surface transportation system that we enjoy. It would seem that a large market could be developed for V/STOL aircraft in those countries that are attempting to develop more rapidly. The research that is ongoing now in NASA and agencies of the Department of Defense on V/STOL aircraft would result in new more efficient machines that could be very useful in expanding the economies of developing nations.

In our own country a relatively new transportation system is developing—the commuter airlines. Where there were only a few operating 15 years ago, today there are over 200 operating scheduled services. These carriers, operating small aircraft, have stepped into a void created by the abandonment of service to smaller communities by certificated carriers who could no longer afford to operate their large aircraft at points generating very little traffic. Some of the commuter carriers are carrying more passengers now than did the local service carriers when they were first certificated by the CAB. The commuter airlines are operating U.S. manufactured general aviation aircraft as well as some higher capacity aircraft manufactured outside this country. At present the CAB limits the size of aircraft that can be operated. Should the regulatory climate change as a result of Congressional action a market may be created for a new class of aircraft.

Several references have been made to the essential elements of productivity and cost of operations in air transportation. A major element of operating cost is fuel. At the present time, the airlines together with the FAA are practicing fuel economy measures in their daily operations. However

with the specter of inadequate fuel supplies, future technologies must be developed that will result in reduced fuel consumption. Such research is now being pursued in NASA laboratories. The technical developments aimed at fuel efficiency for subsonic transport aircraft will provide the means of controlling the rising air transportation costs brought about by increases in fuel prices.

The "positive forces" that are working in the market place clearly indicate that requirements do, and will exist for all types of new aircraft. The distant markets will require a new class of transports, both passenger and cargo carriers. Potentially strong markets are in the formative stage for many types of V/STOL aircraft. At home, a market may be developing for the proverbial "DC-3 replacement."

Continued leadership in aeronautics is a must in maintaining a healthy industry. The competition that is growing in other countries should be a catalyst to our own efforts.

Aviation will always have a place in world commerce. However, if new developments are not pursued with vigor aviation will not assume the dominant role it can achieve.

The world does need more and better aircraft. However, the environment in which tomorrow's aircraft will develop may be different.

The business environment relative to the production of new aircraft could be very much different than the one which is operative today. The massive amounts of capital required to launch a new venture could be quite beyond the financial capacity of an individual manufacturer. The next generation of air vehicles will probably be larger and consequently more expensive which will increase initial capital requirements. Also, as aircraft become larger—and more productive—the total number of aircraft required to meet market demands may be of insufficient quantity to justify several production lines. Thus it is not inconceivable that the next generation of aircraft produced by U.S. manufacturers might be the product of joint-venture activities or of mergers or both. Multinational manufacturing activities have been a fact of life for many years in several product lines.

It is not beyond the realm of possibility that airframe manufacturers in the U.S. might find it convenient if not necessary to undertake joint ventures with those of foreign nations to successfully market new vehicles.

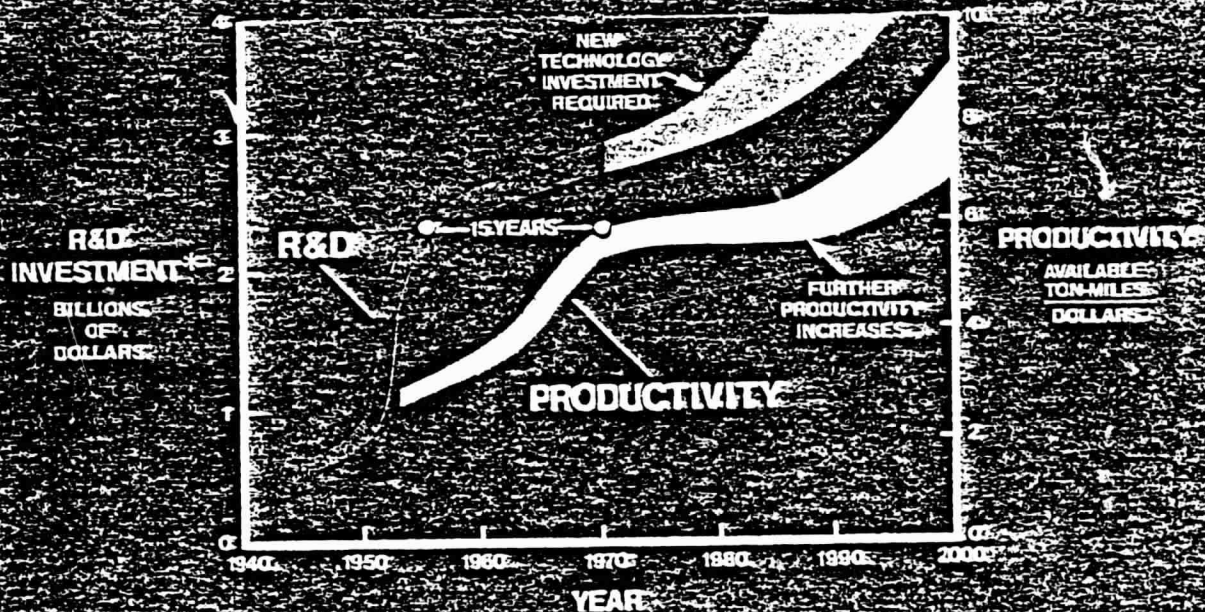
All our major airframe manufacturers have had large military contracts that have provided a strong base for operations. With military contracts dwindling, manufacturers may find it increasingly difficult to remain profitable. Since it is the stated policy of the United States to maintain our leadership in the aeronautics industry of the world, it may be necessary that the government find other ways to support this vital industry other than through military contracts. Precedent has already been established for such activities. The U.S. supersonic aircraft program was originally undertaken with government support. More recently the Lockheed Corporation has had the benefit of government guaranteed loans. Depending upon the way the future situation of the aircraft industry develops--and in order to maintain a strong national manufacturing base--some form of congressional action may be necessary.

Social pressures during the last 10 years have forced the aviation community to find ways of becoming a better neighbor. During the late 1960's noise and air pollution resulted in the promulgation of certain standards limiting these undesirable side effects of aviation. NASA has been in the vanguard of efforts to find ways to reduce both air pollution and noise. Several research programs have already borne fruit and other programs are continuing. There is no question that the aeronautics industry should continue the effort to eliminate as much noise and air pollution as possible. However there are many difficult problems to solve that will require much time as well as money to find answers that will result in efficient air vehicles and at the same time be acceptable to society as a whole.

In summary, ongoing research programs point to a variety of aircraft that may well evolve as part of the aviation system of the future. Improved rotorcraft, and short field powered-lift aircraft, together with military and naval aircraft of similar characteristics will serve a variety of needs. The most significant improvements in short range air transportation, however, will come with the introduction of quiet all-weather VTOL transport aircraft. The same technology may also see application in special purpose surface effect aircraft. The next generation of subsonic transport aircraft

will provide greater fuel efficiency for civil air transportation and longer range and endurance for military aircraft. The greatest impact on long range air transportation will result from the introduction of an efficient, environmentally acceptable supersonic transport. This development may pave the way ultimately to hypersonic aircraft of even greater speed and range. The significance of air transportation of quiet VTOL aircraft and efficient long range supersonic transports is such that the technology should be developed to the point where the U.S. industry can move rapidly and with confidence to build these aircraft.

NASA OUTLOOK FOR AERONAUTICS AVIATION GROWTH 1940-2000



*1967 DOLLARS

FIGURE 1

NASA OUTLOOK FOR AERONAUTICS
CONTROLLING FACTORS
IN AVIATION
1980-2000

**CIVIL
AVIATION**

- INCREASING COSTS OF AIR TRANSPORTATION
- CONGESTION OF THE AIR SYSTEM
- FOREIGN COMPETITION IN ADVANCED AIRCRAFT

**MILITARY
AVIATION**

- REDUCED ACCESS TO OVERSEAS REFUELING SITES
- FEWER FOREIGN LOGISTICS AND STAGING AREAS
- HIGH COST OF NEW WEAPONS SYSTEMS

FIGURE 2

NASA OUTLOOK FOR AERONAUTICS

AIRLINE COST TRENDS

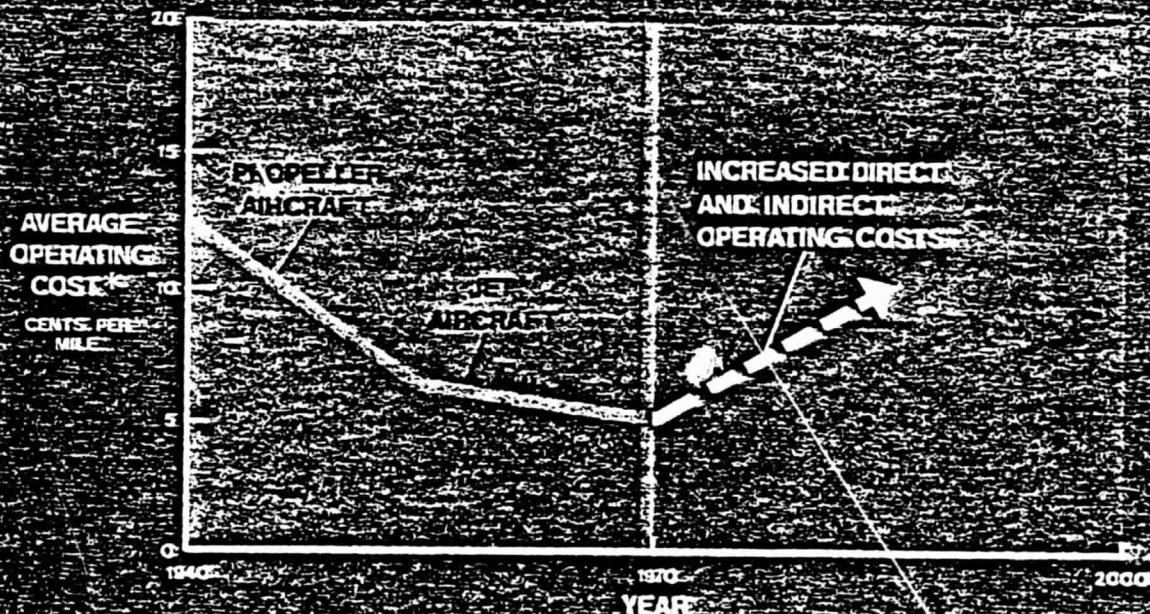


FIGURE 3

NASA OUTLOOK FOR AERONAUTICS

AIR SYSTEM CONGESTION

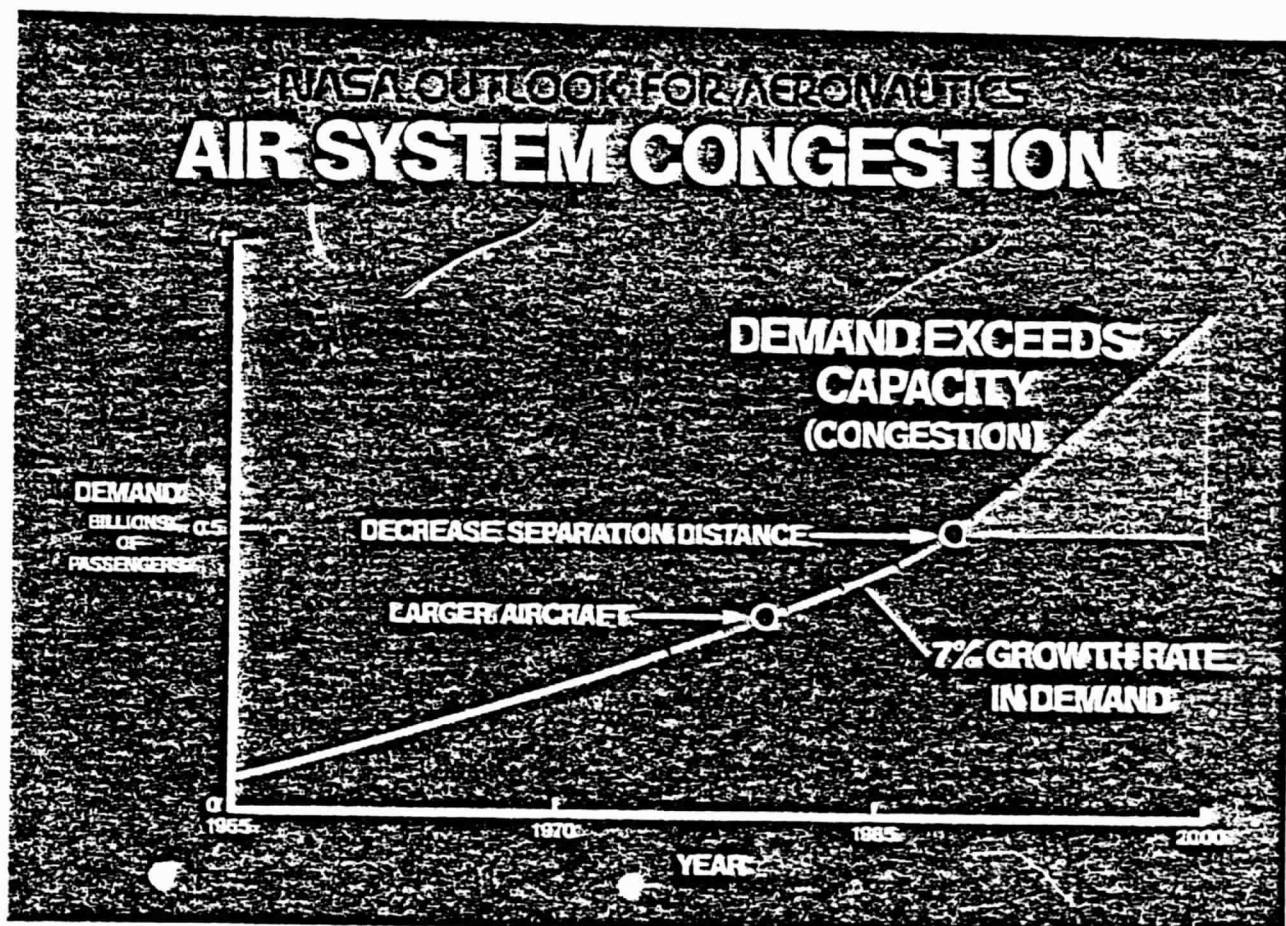


FIGURE 4

NASA OUTLOOK FOR AERONAUTICS
FOREIGN COMPETITION
LONG RANGE AIRCRAFT



CONCORDE



AIRBUS 300

SHORT RANGE AIRCRAFT



DASH-7



VFW 614



DAUPHIN



HARRIER

FIGURE 5

NASA OUTLOOK FOR AERONAUTICS

REDUCED AIRCRAFT WEIGHT

PERFORMANCE IMPROVEMENT



FIGURE 6

NASA OUTLOOK FOR AERONAUTICS FEWER FOREIGN LOGISTICS AND STAGING AREAS

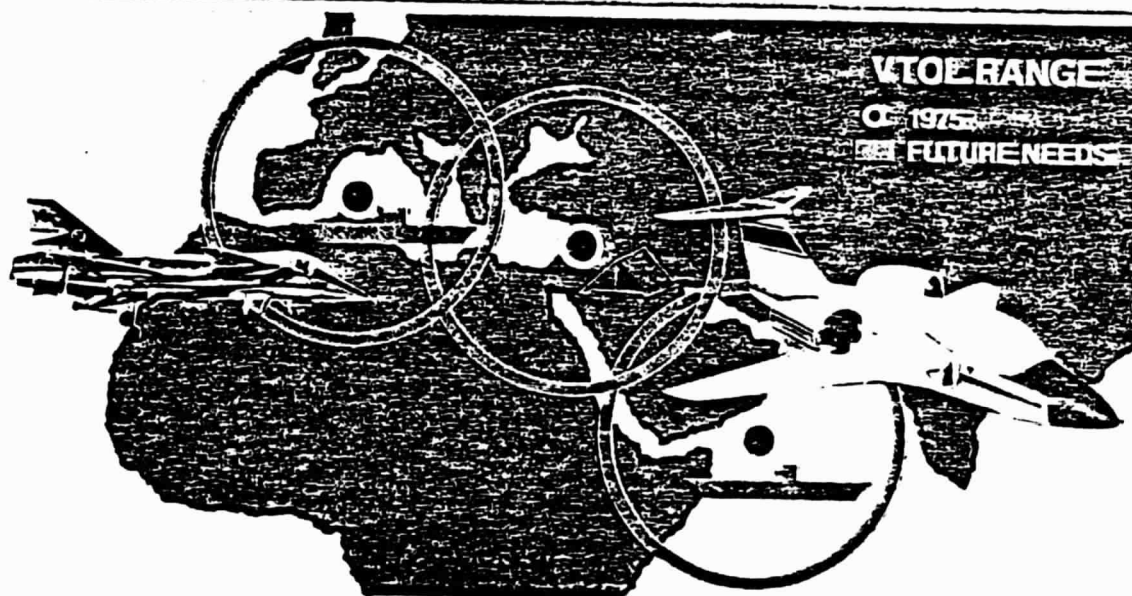


FIGURE 7

NASA OUTLOOK FOR AERONAUTICS

HIGH COST OF WEAPONS SYSTEMS

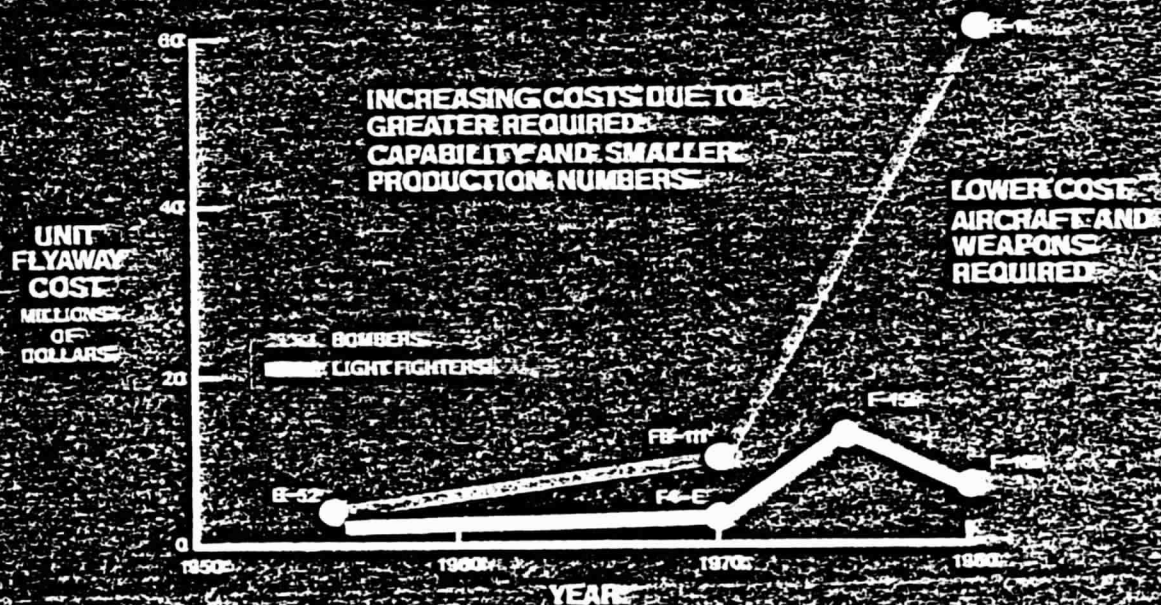


FIGURE 8

NASA OUTLOOK FOR AERONAUTICS

FUTURE DIRECTIONS IN AERONAUTICAL DEVELOPMENT

- TOWARD GREATER EFFICIENCY AND ECONOMY IN SUBSONIC PASSENGER AND CARGO AIR SERVICE AND IMPROVED SAFETY IN GENERAL AVIATION
- TOWARD GREATLY IMPROVED SHORT-HAUL AIR SERVICE IN HIGH AND MEDIUM DENSITY POPULATION AREAS
- TOWARD EFFICIENT SUPERSONIC TRANSOCEANIC LONG RANGE FLIGHT
- TOWARD LONG ENDURANCE SURVEILLANCE AND LONG RANGE AIR SUPPLY UTILIZING ADVANCED SUBSONIC AIRCRAFT
- TOWARD MORE EFFECTIVE SHORT RANGE SUPPORT & LOGISTICS CAPABILITIES UTILIZING MULTI-MISSION ROTORCRAFT AND V/STOL AIRCRAFT
- TOWARD MORE EFFECTIVE TACTICAL SYSTEMS COMPRISING FIGHTER AIRCRAFT, ADVANCED WEAPONS & REMOTELY PILOTED VEHICLES

FIGURE 9

NASA OUTLOOK FOR AERONAUTICS NEW OPPORTUNITIES

- **CREATE CENTERS OF COMMERCE AND TRADE THAT WOULD BRING ABOUT REDEVELOPMENT OF CITY CENTERS**
- **STIMULATE WORLD TRADE AND COMMUNICATION AND A GREATER LEVEL OF UNDERSTANDING BETWEEN NATIONS**
- **PROVIDE NEW FLEXIBILITY IN LOCATING CENTERS OF PRODUCTION AND IMPROVING DEMOGRAPHIC PATTERNS IN THE U.S. AND DEVELOPING NATIONS**

FIGURE 10

NASA OUTLOOK FOR AERONAUTICS AVIATION SYSTEM

● AN INTERCITY AIR SYSTEM USING SMALL AIRPORTS AND QUIET VTOL AIRCRAFT

● FAST INTERCONTINENTAL AIR SYSTEM USING OFFSHORE TERMINALS AND LONG RANGE SUPERSONIC AIRCRAFT

● AN INTEGRATED AIR CARGO, WAREHOUSING AND DISTRIBUTION SYSTEM USING VERY LARGE CARGO AIRCRAFT

FIGURE 11

ENERGY EFFICIENT TRANSPORT

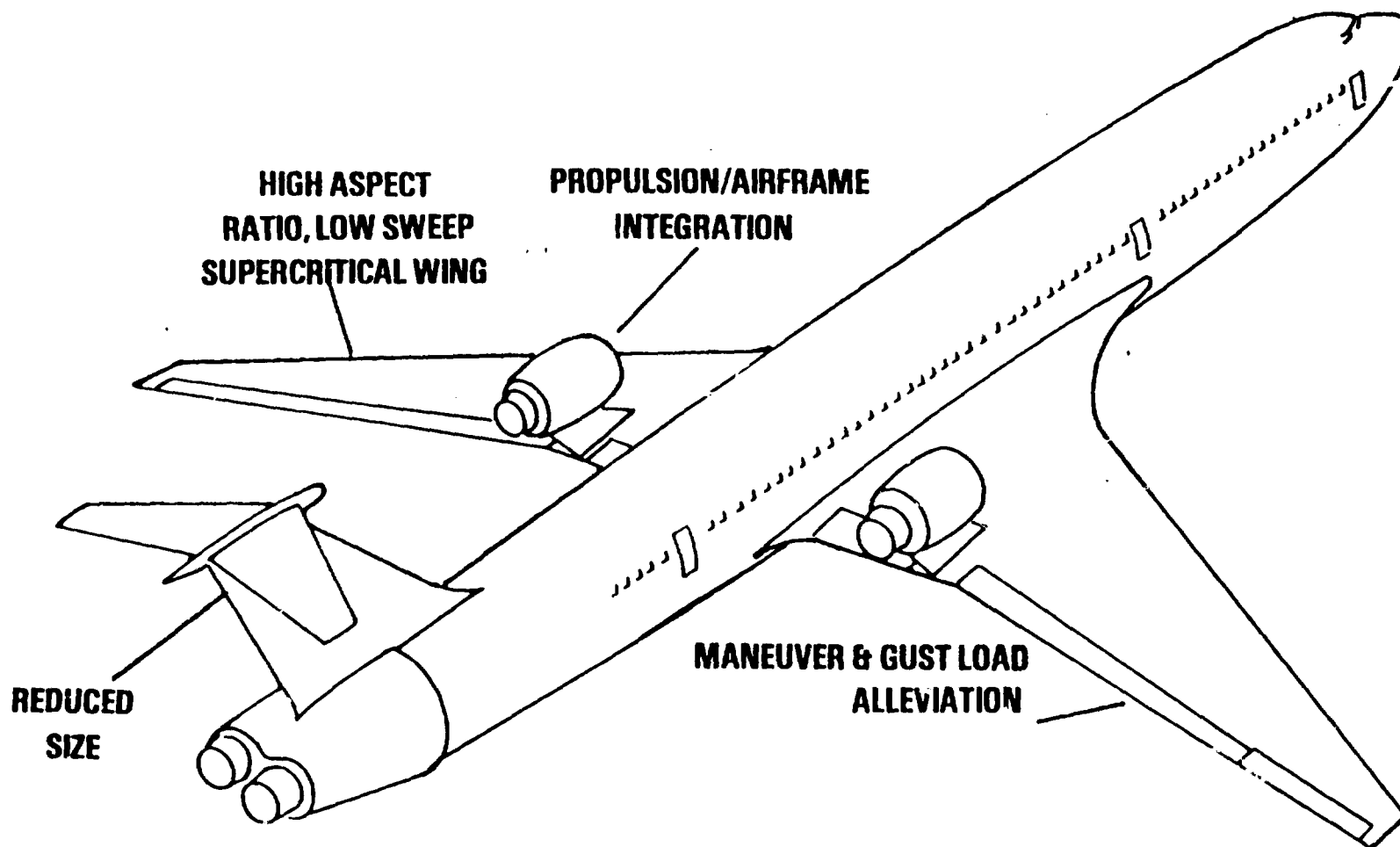
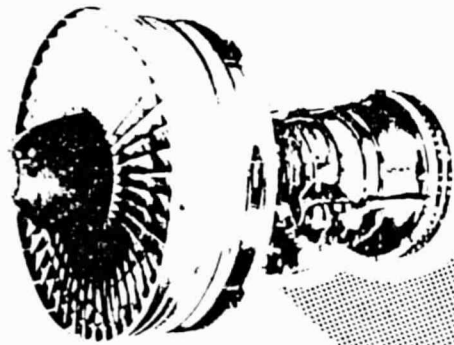


FIGURE 12

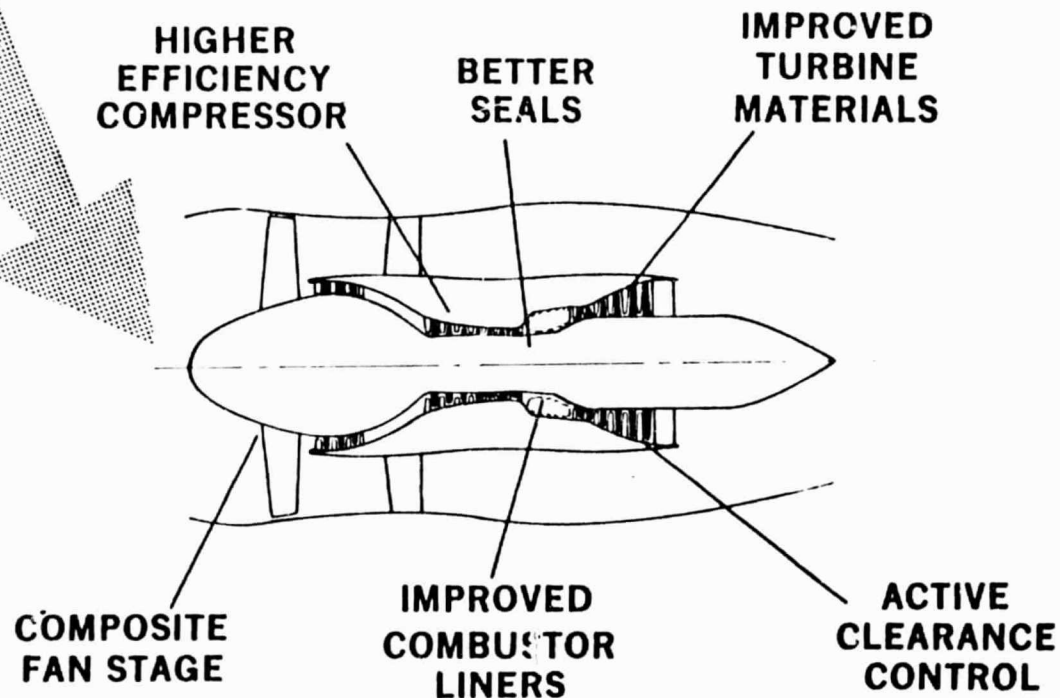
ENERGY EFFICIENT ENGINE

1985 ADVANCED ENGINE TECHNOLOGY

- HIGHER TEMPERATURE
- HIGHER PRESSURE
- 10% EFFICIENCY IMPROVEMENT



**TYPICAL 1975
ENGINE
TECHNOLOGY**

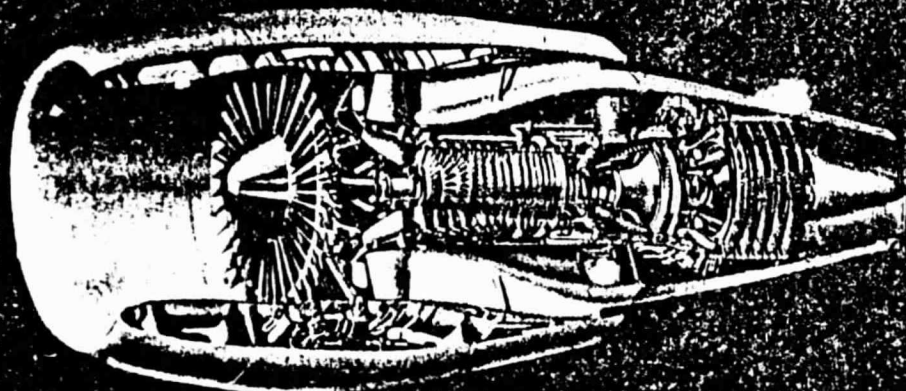


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FIGURE 13

FUTURE OPPORTUNITY—AERONAUTICS FUEL CONSERVATION

EFFICIENT PROPULSION TECHNIQUES FOR REDUCED FUEL CONSUMPTION



1. 15% REDUCTION IN GROSS WEIGHT OF PROPULSION SYSTEM
2. IMPROVED COMBUSTION EFFICIENCY AT IDLE & LOW-THRUST MODES
3. 30% REDUCTION IN CONSUMED FUEL BY INCREASING POWER YIELD

**ADVANCED COMPONENT
TECHNOLOGY TURBOFAN
ENGINE**

LIGHTWEIGHT COMPOSITE FAN FRAME

**COMPOSITE FAN
BLADE**

PITCH CHANGE MECHANISM

**ADVANCED COMPRESSOR
WITH ADJUSTABLE
STATORS**

**MINIMUM EMISSION COMBUSTOR
CERAMIC TURBINE VANE**

HIGH WORK FACTOR TURBINE STAGES

REDUCED ENGINE SIZE

HIGH SPEED BEARINGS & SEALS

**CURRENT TECHNOLOGY
TURBOFAN ENGINE**

FAN

COMPRESSOR

COMBUSTOR

TURBINE

FIGURE 14

LAMINAR FLOW CONTROL FUEL CONSERVATION POTENTIAL

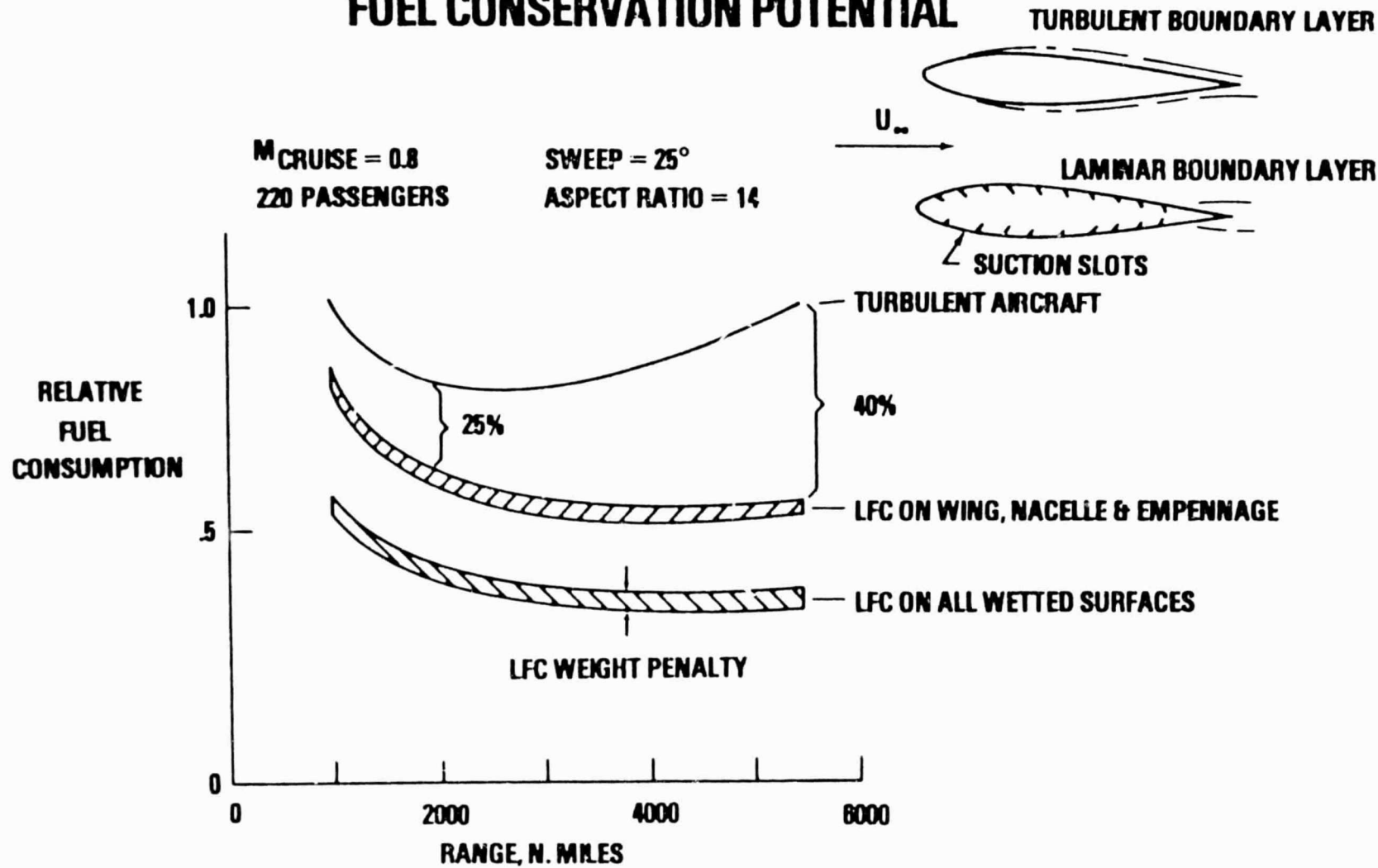


FIGURE 15

X-21 LAMINAR—FLOW—CONTROL AIRCRAFT

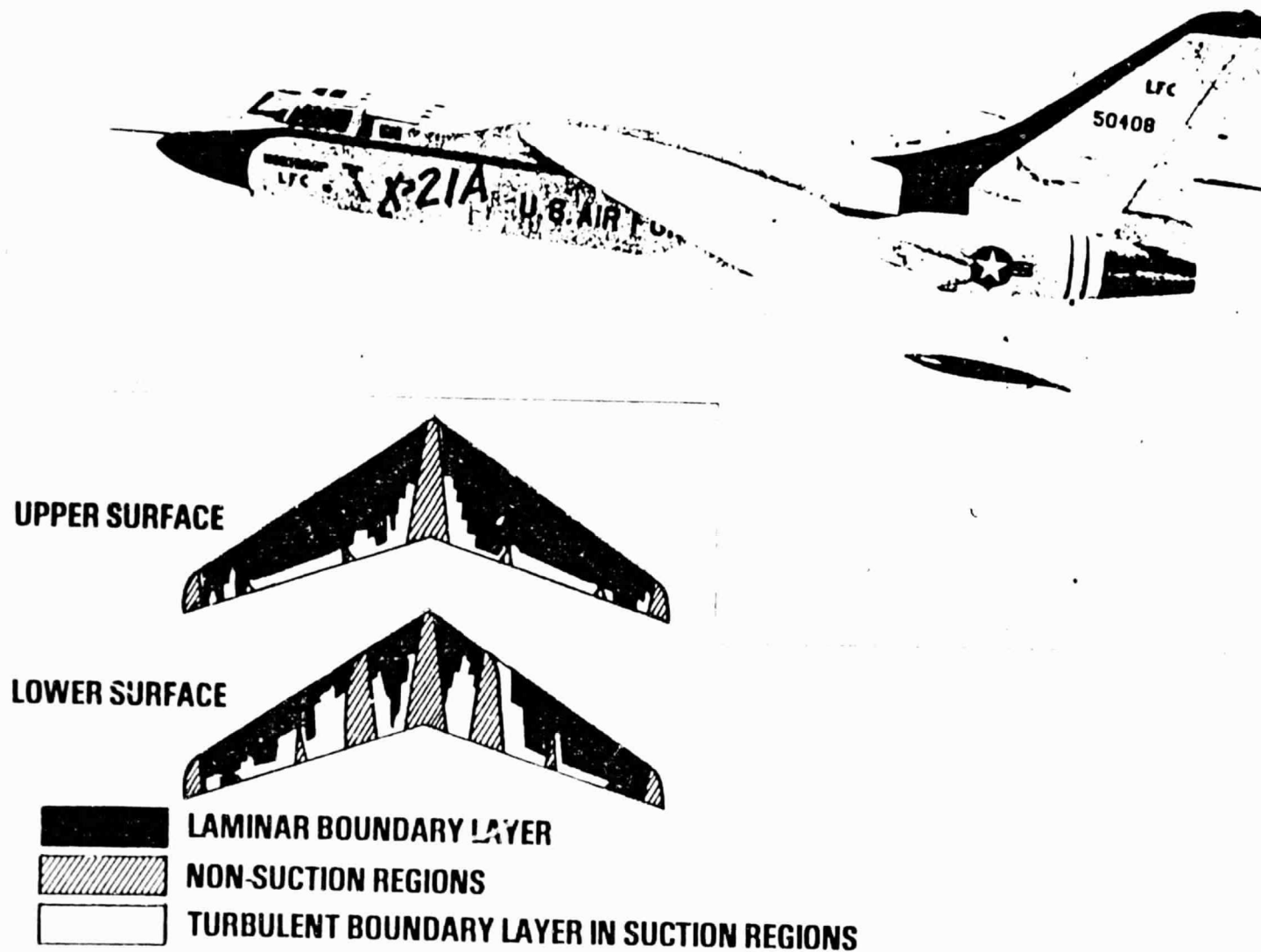
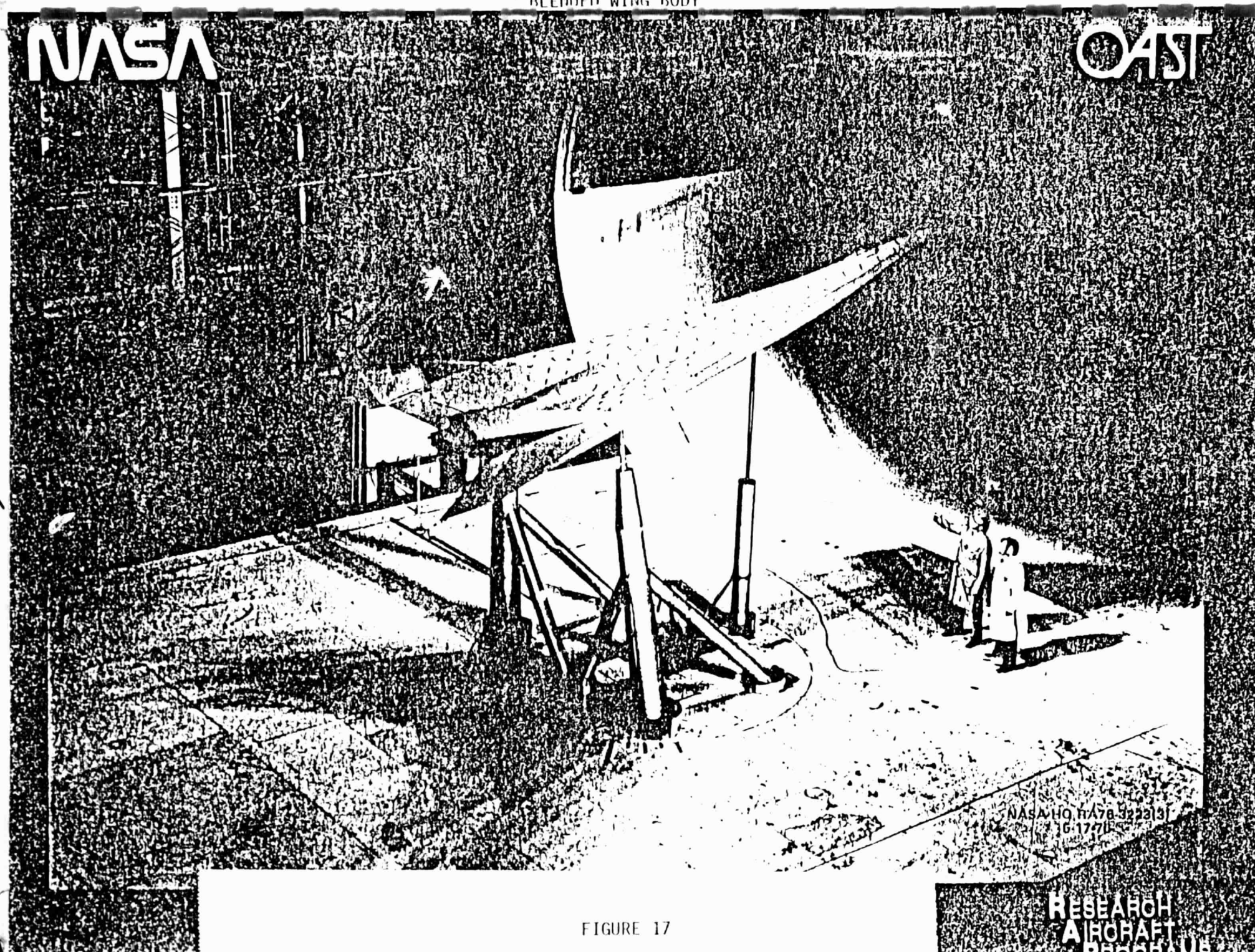


FIGURE 16

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FIGURE 17

RESEARCH
AIRCRAFT

SUPERSONIC CRUISE AIRCRAFT RESEARCH CONCEPTS



ARROW WING

BLENDED WING BODY

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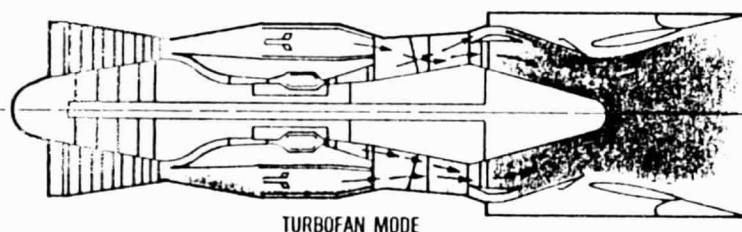
FIGURE 18

SUPERSONIC CRUISE AIRCRAFT RESEARCH

SPECIFIC FUEL CONSUMPTION COMPARISON (MULTI-CYCLE ENGINE VS. AFTER BURNING TURBOJET ENGINE)

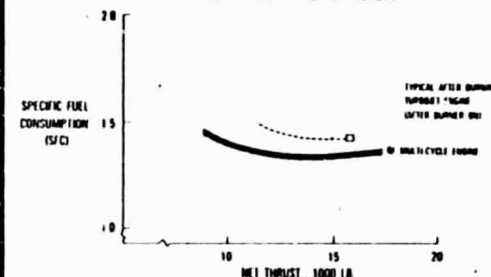
MULTI-CYCLE ENGINE

TURBOJET MODE

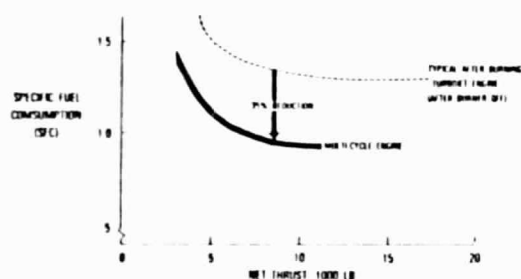


TURBOFAN MODE

SUPERSONIC OPERATION



SUBSONIC OPERATION



NASA HQ RL76-867(3)
10-22-75

FIGURE 19

IMPACT OF TECHNOLOGY ON AIRCRAFT NOISE LEVELS

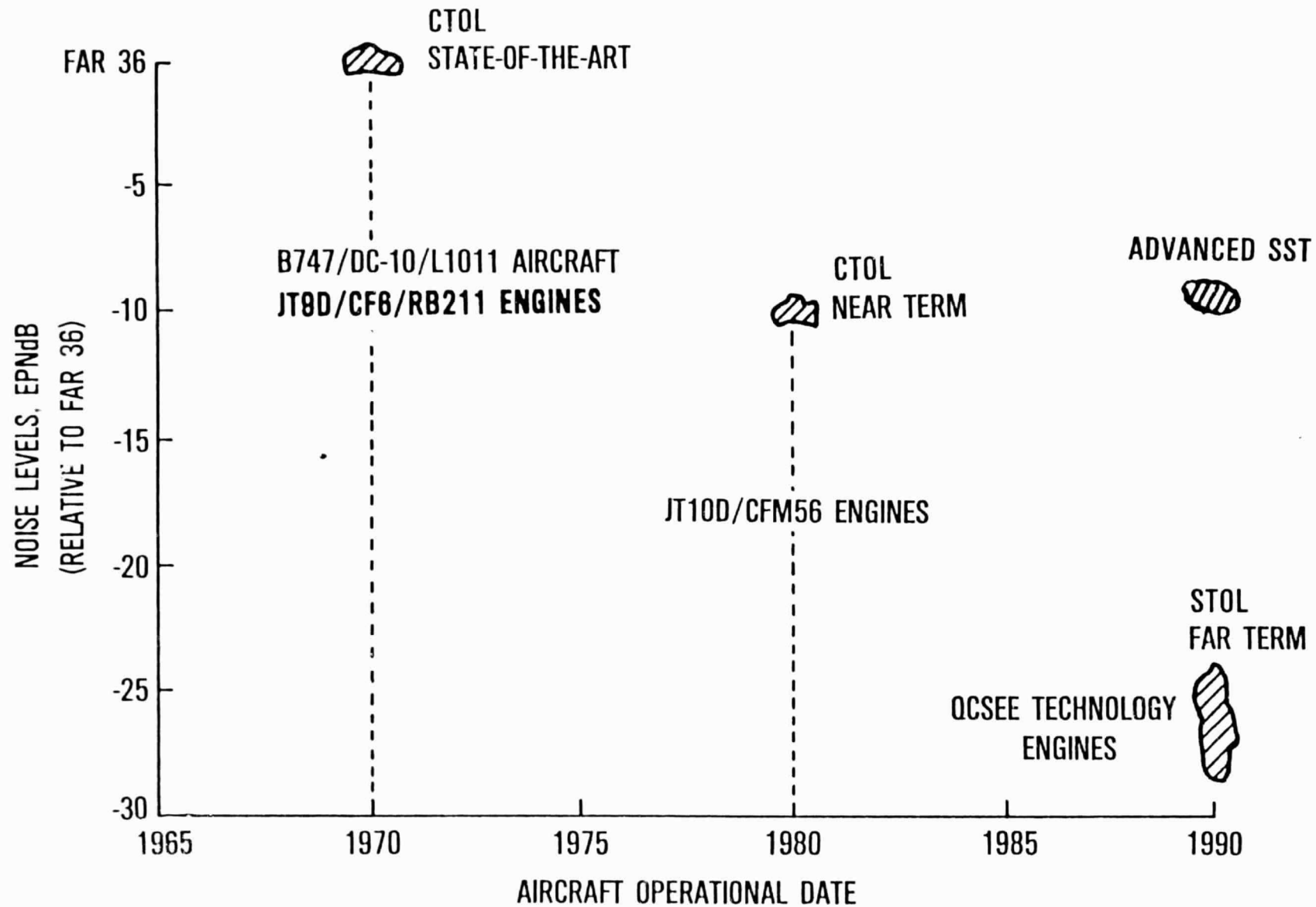


FIGURE 20

IMPACT OF TECHNOLOGY ON AIRCRAFT POLLUTION LEVELS

(NO_x AT SEA LEVEL TAKE-OFF CONDITIONS)

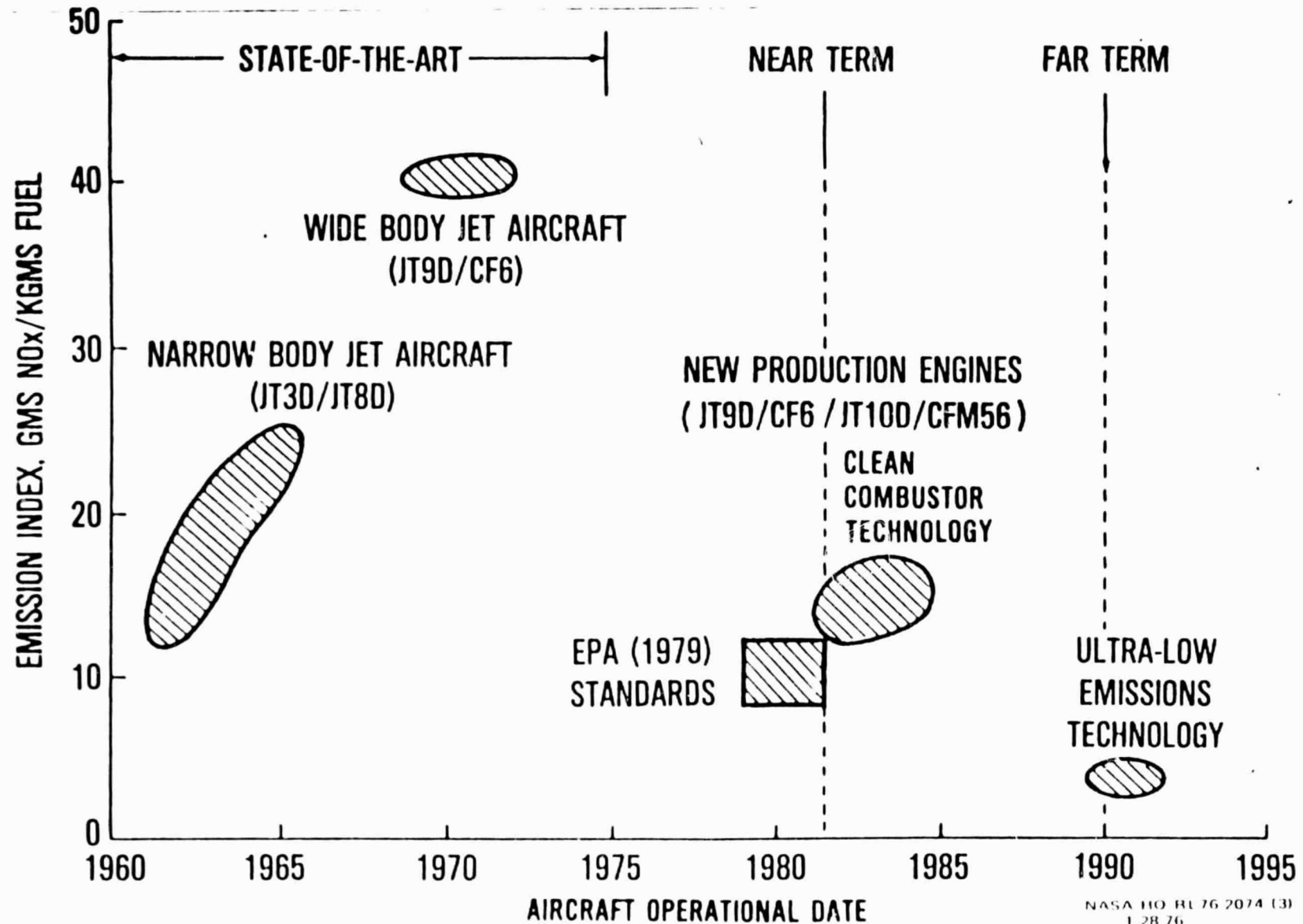


FIGURE 21

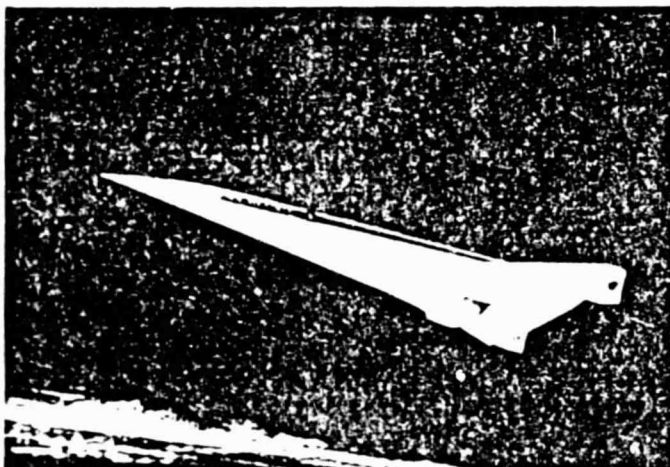
HYPERSONIC APPLICATIONS



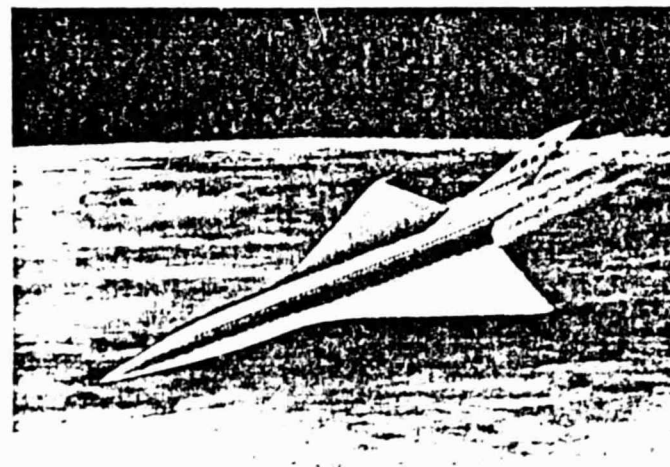
ADVANCED AIR DEFENSE
MACH 4.5



AIR-BREATHING LAUNCH
MACH 6-10



STRIKE/RECONNAISSANCE
MACH 12



HYPERSONIC TRANSPORT
MACH 6-8

NASA HO-RI-76-1628-CD
1-5-76

HYPERSONIC AIRCRAFT

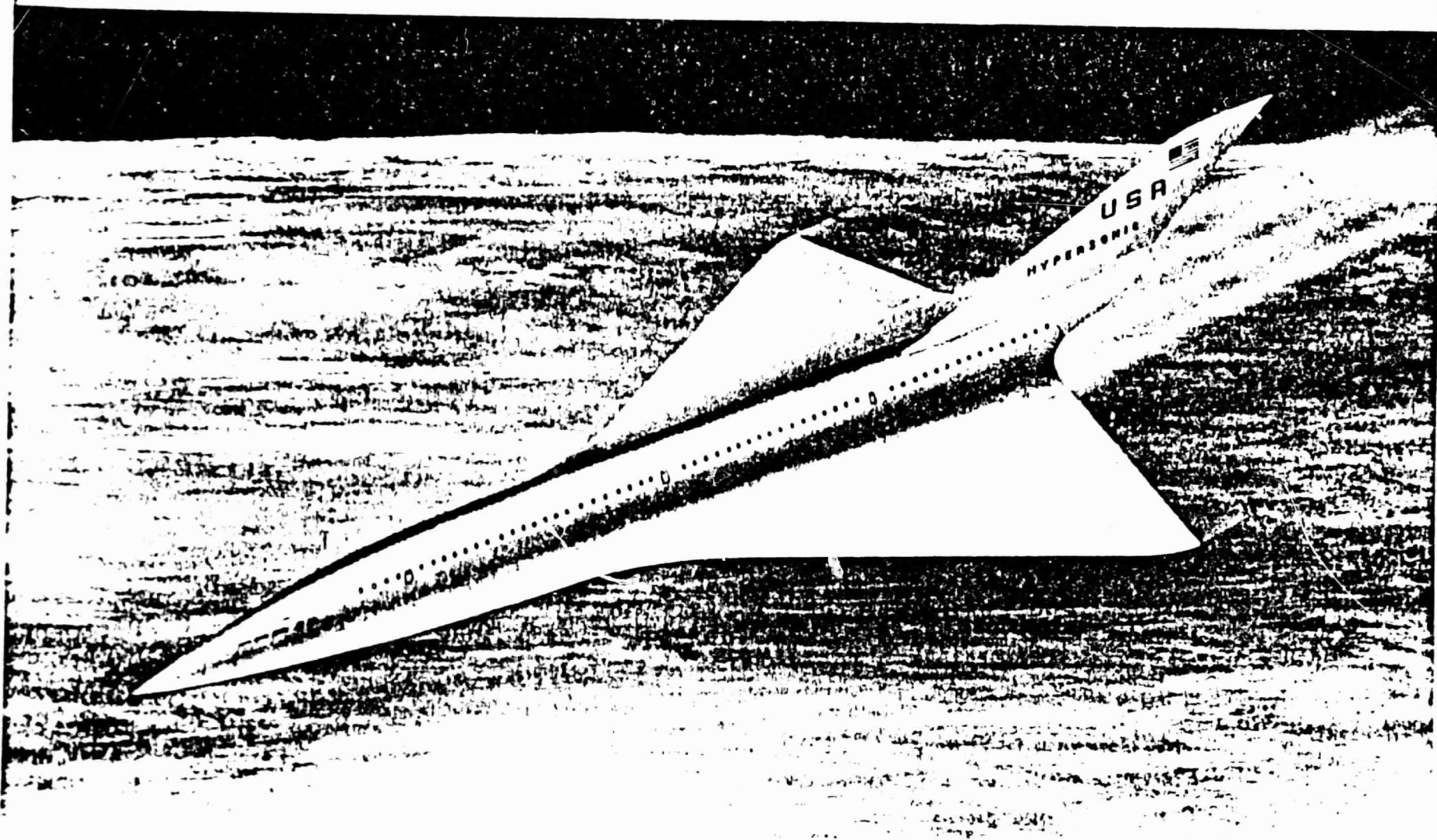
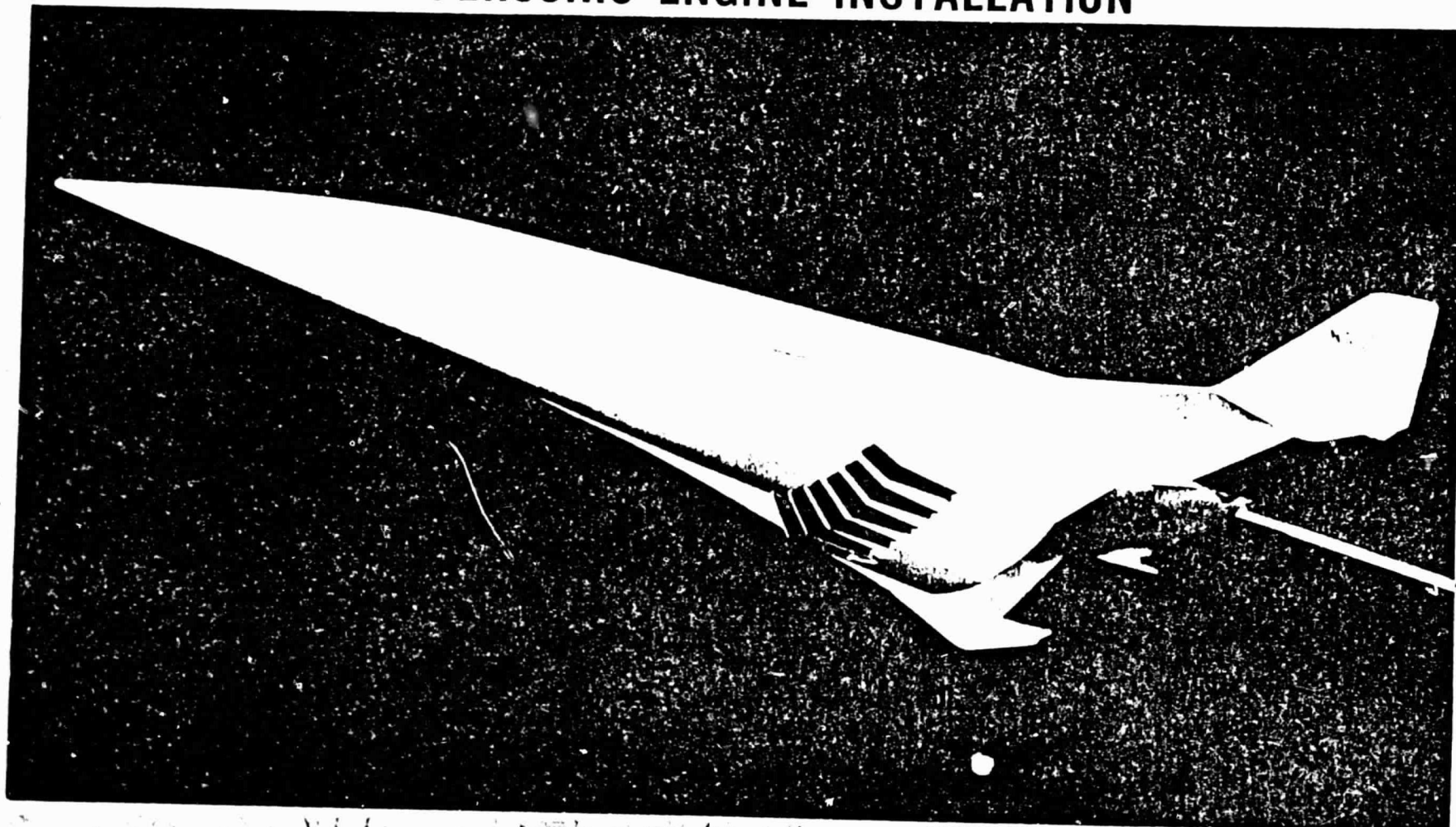


FIGURE 23

NASA R175-2681 (3)
7-24-74

HYPERSONIC ENGINE INSTALLATION



NASA RT75-2682 (3)
7-24-74

FIGURE 24

SUPERSONIC AIR TERMINAL

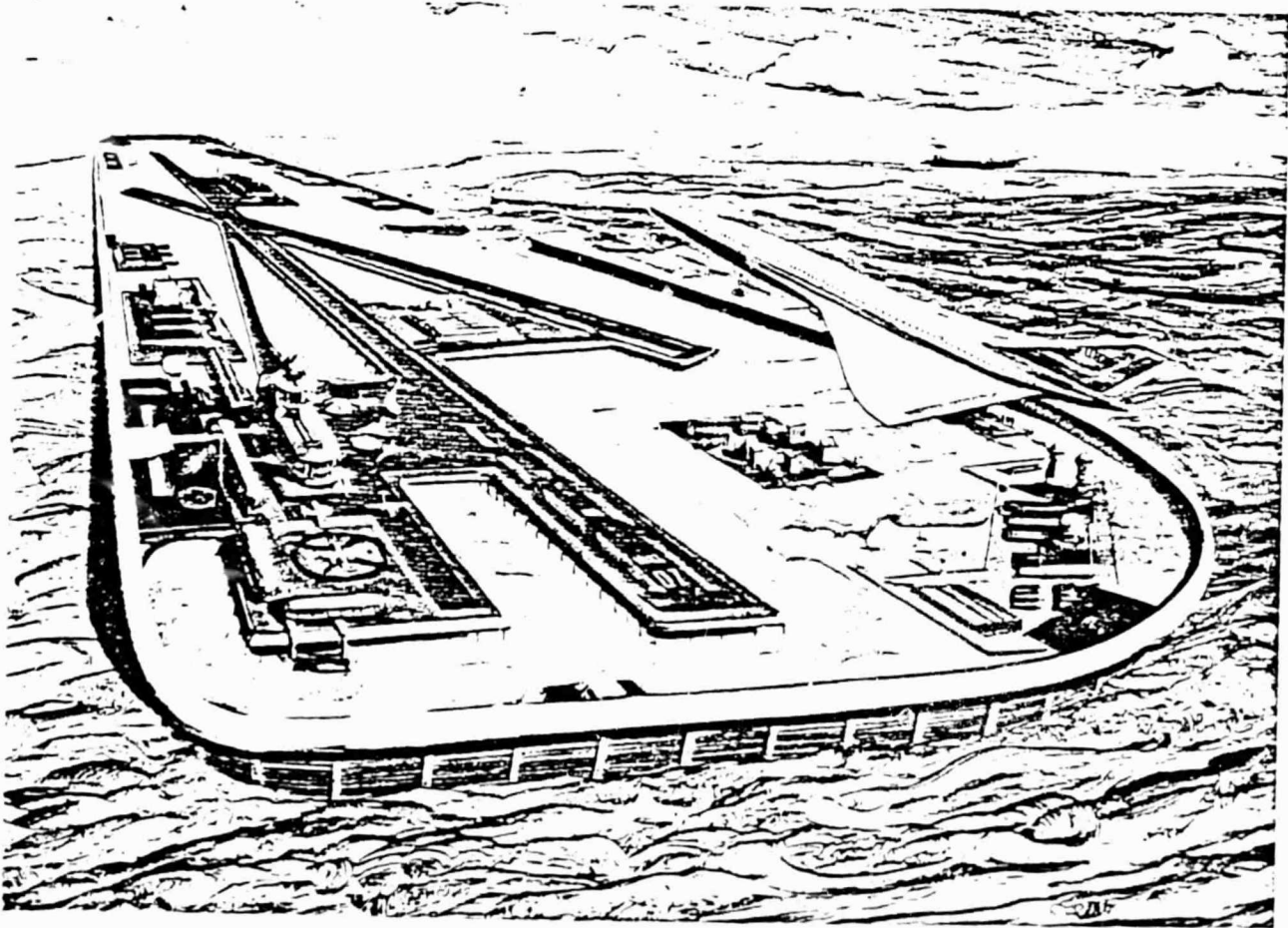


FIGURE 25

NASA UPPER-SURFACE-BLOWN PROPULSIVE-LIFT FLIGHT RESEARCH

USAF/BOEING YC-14 AMST

ENGINE INLET ACOUSTICS

WING FLAP AERO-ACOUSTICS LOADS
AND THERMAL ENVIRONMENT

FUSELAGE CABIN AND EXTERNAL ACOUSTIC NOISE

FIGURE 26

NASA EXTERNAL-BLOWN-FLAP PROPULSIVE-LIFT FLIGHT RESEARCH

USAF/McDONNELL-DOUGLAS YC-15 AMST

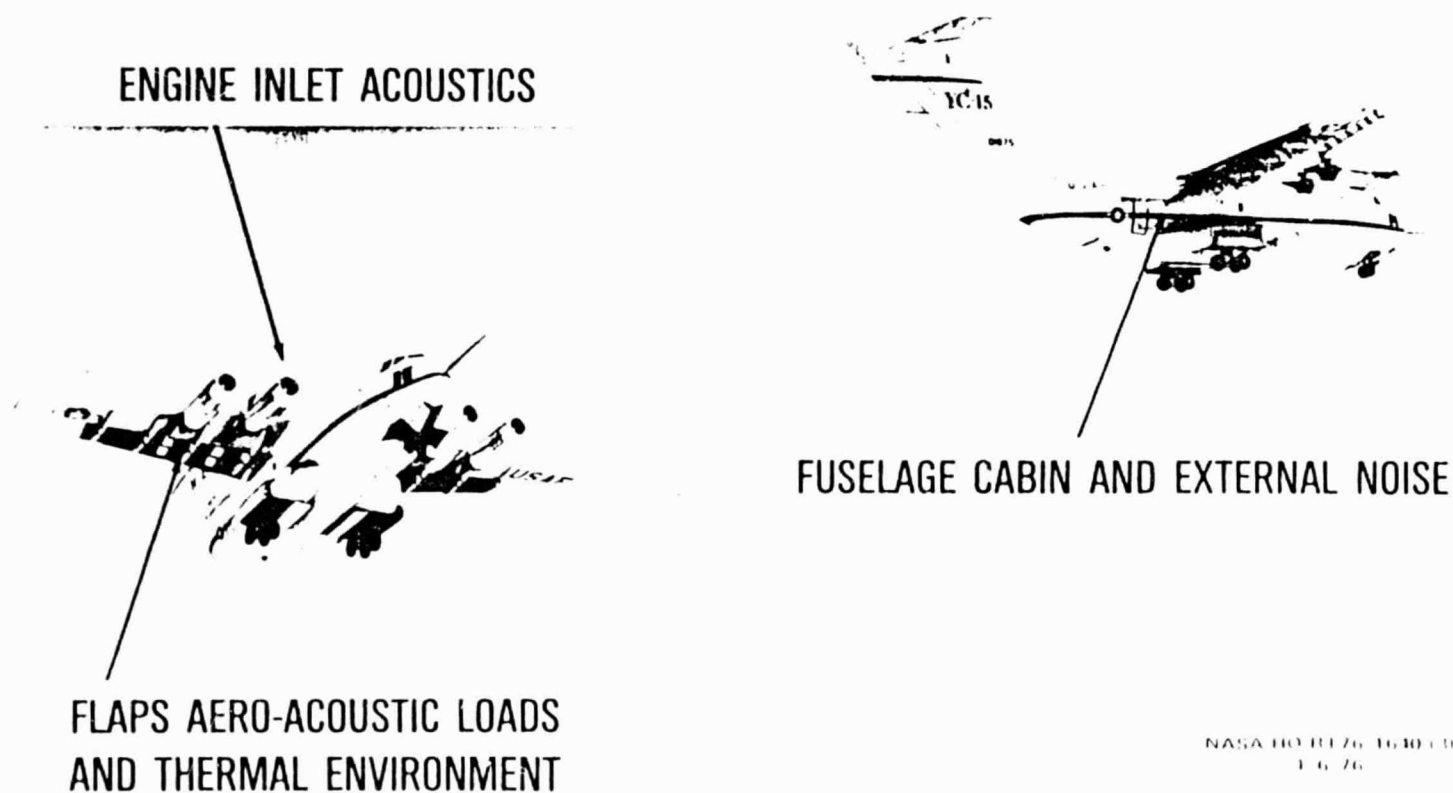


FIGURE 27

QUIET SHORT-HAUL RESEARCH AIRCRAFT

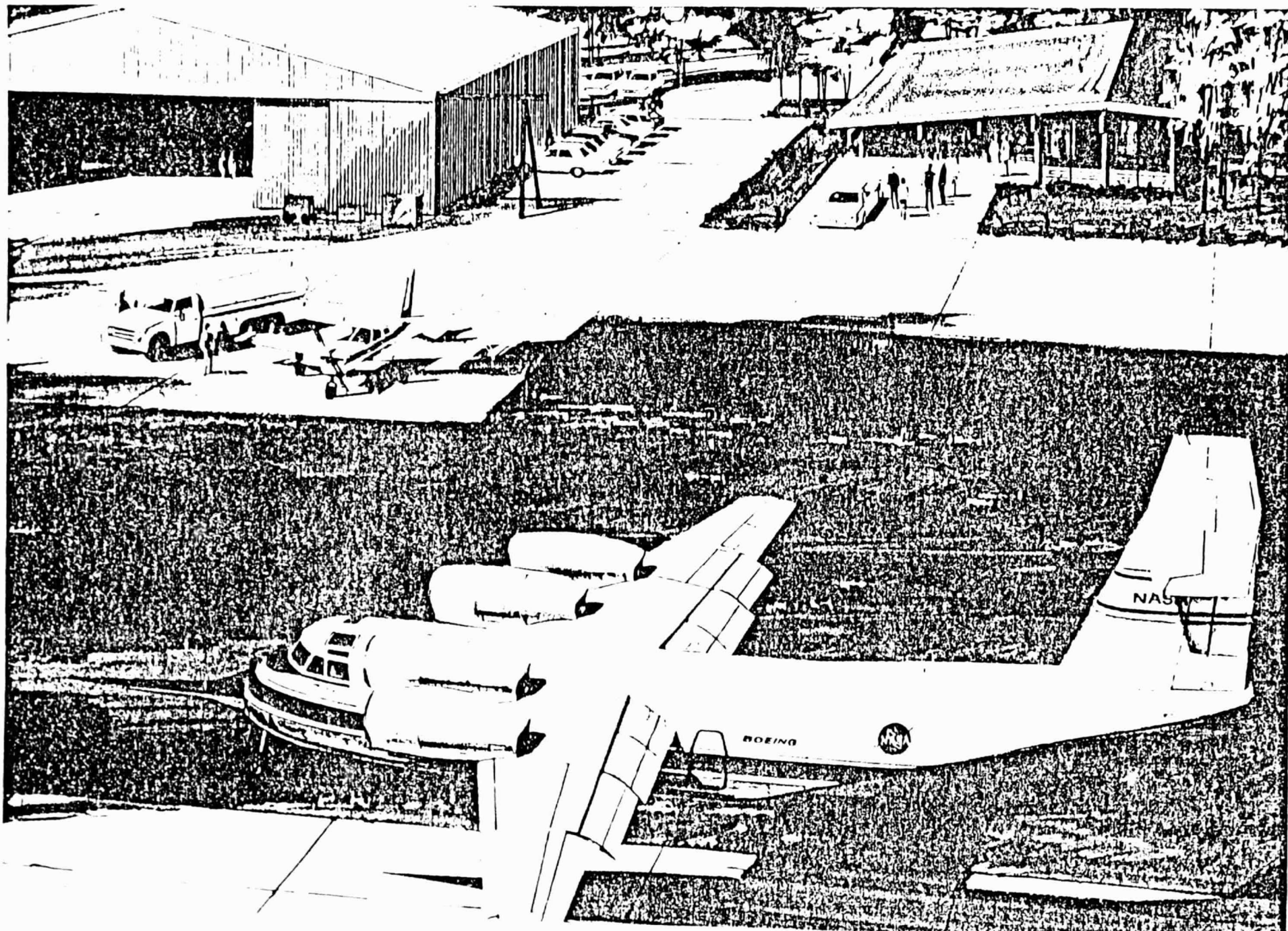
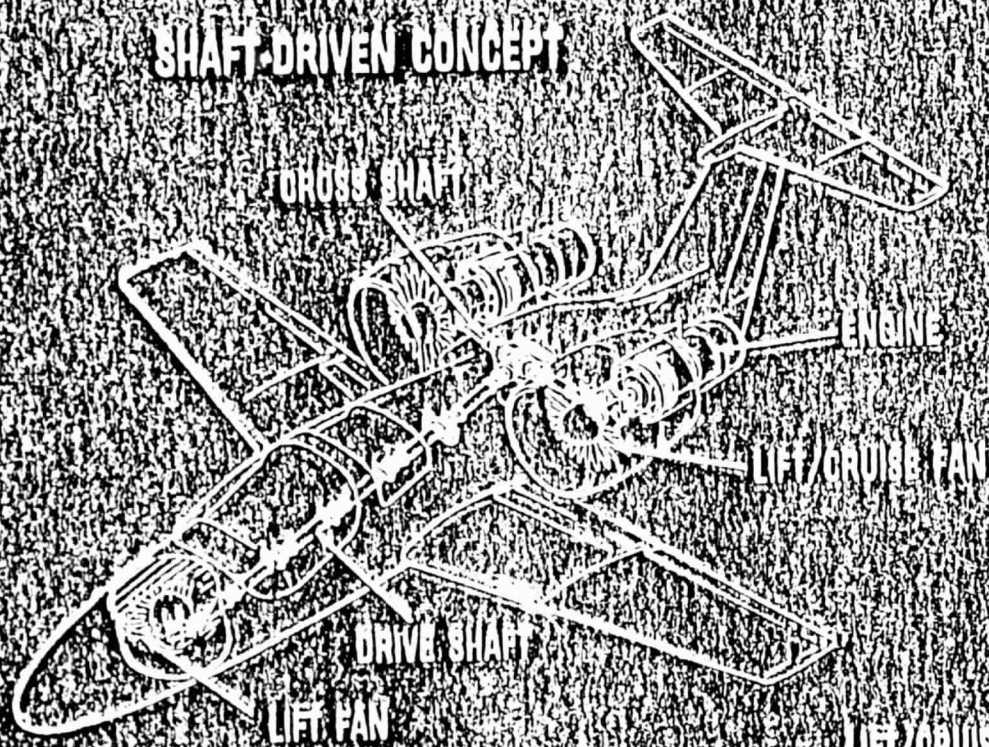


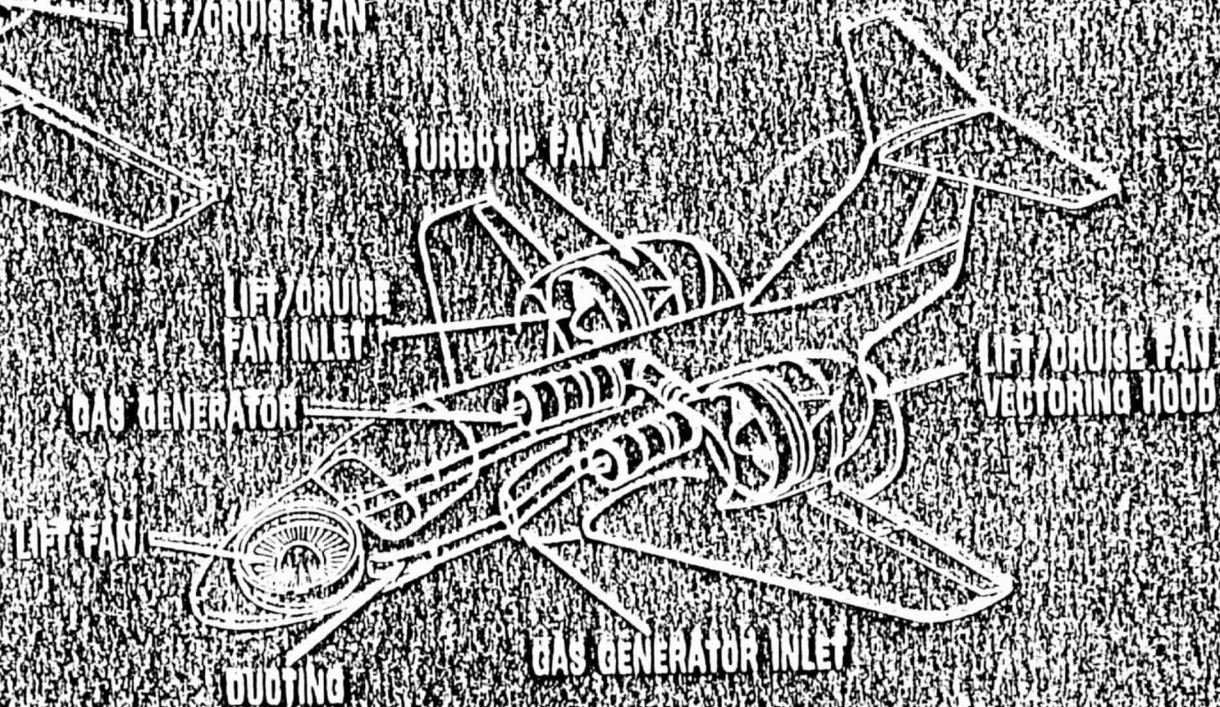
FIGURE 28

LIFT/CRUISE FAN AIRCRAFT CONFIGURATION

SHAFT-DRIVEN CONCEPT

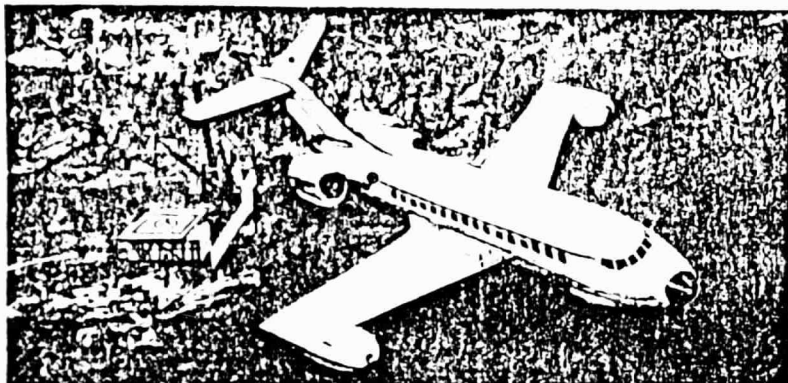


GAS TIP-DRIVEN CONCEPT



NASA 16 RH-1058 (3)
1978

FIGURE 29



TYPICAL LIFT-FAN AIRCRAFT

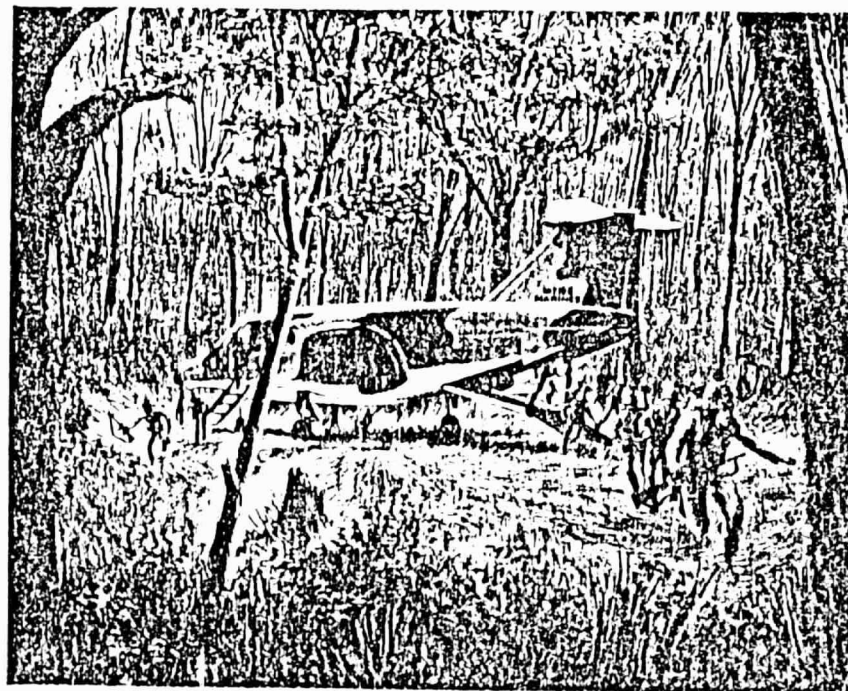
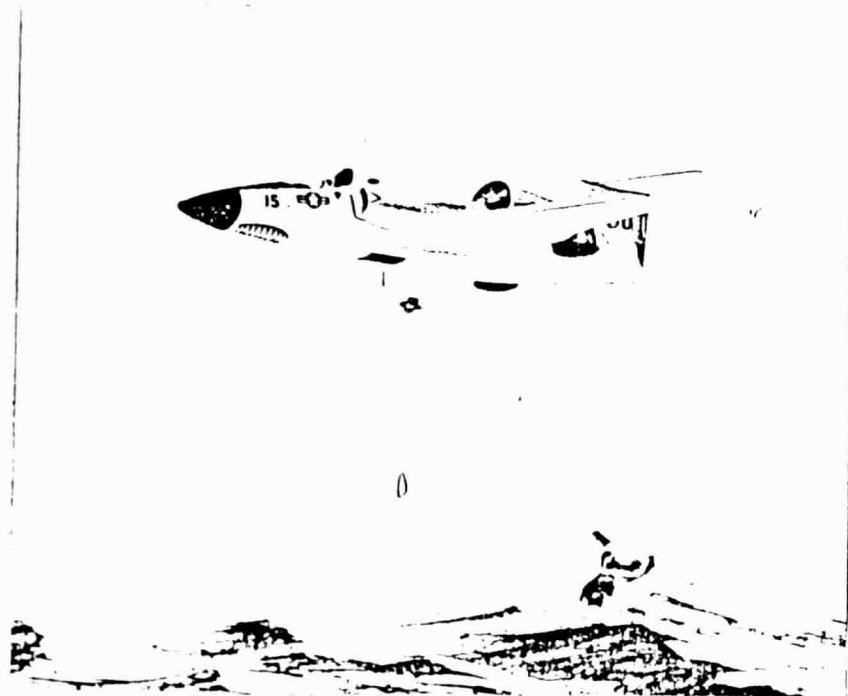
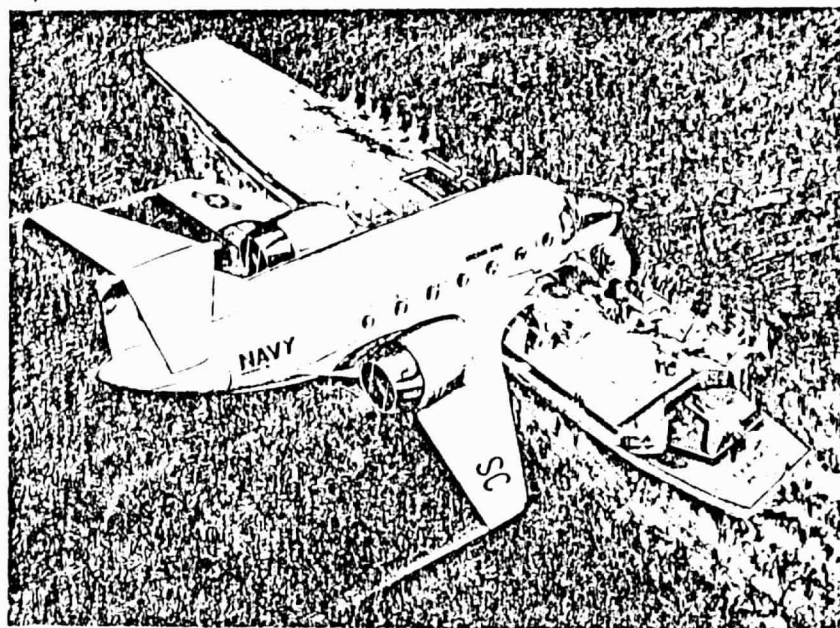


FIGURE 30

ADVANCED ROTORCRAFT

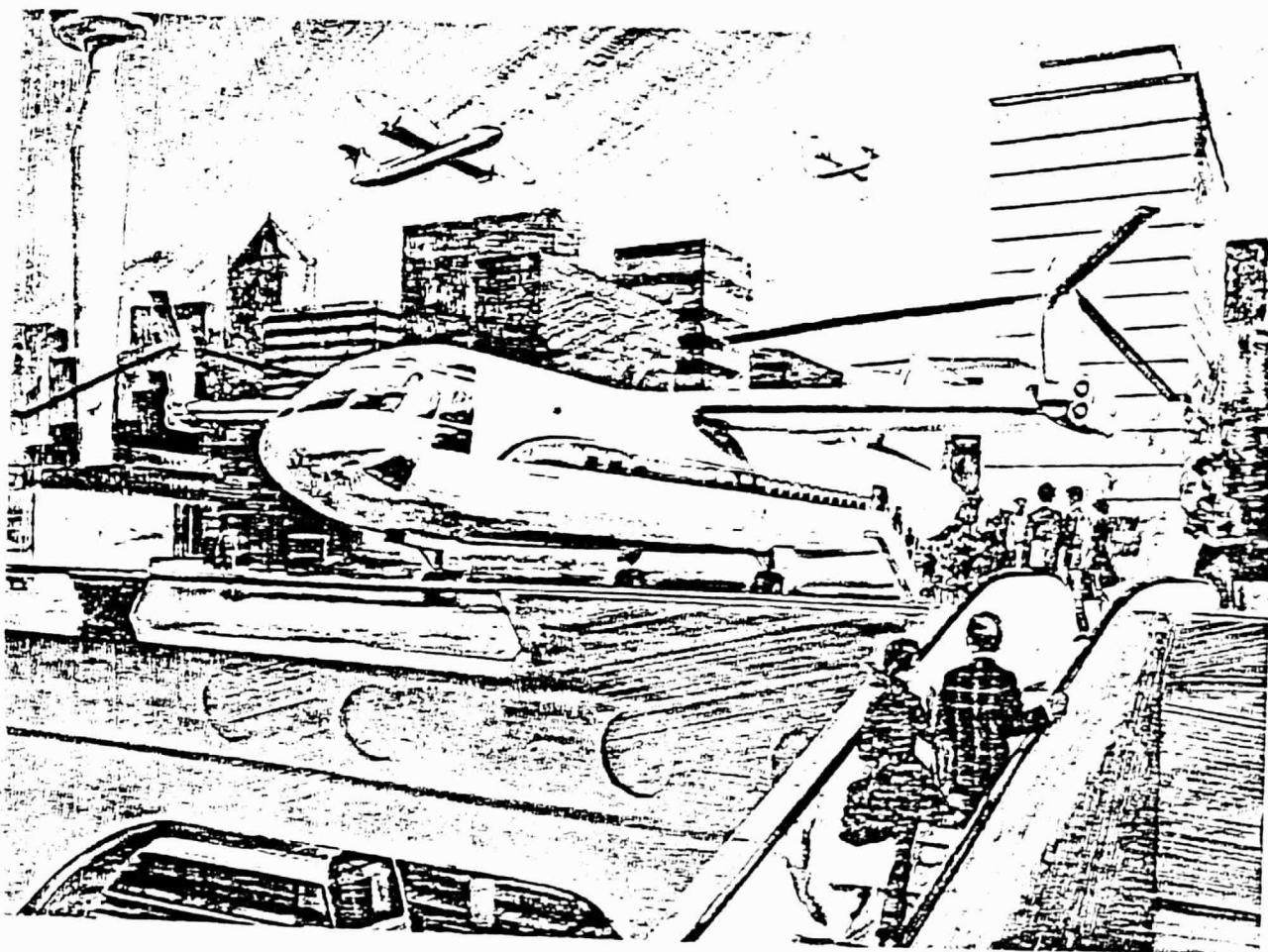
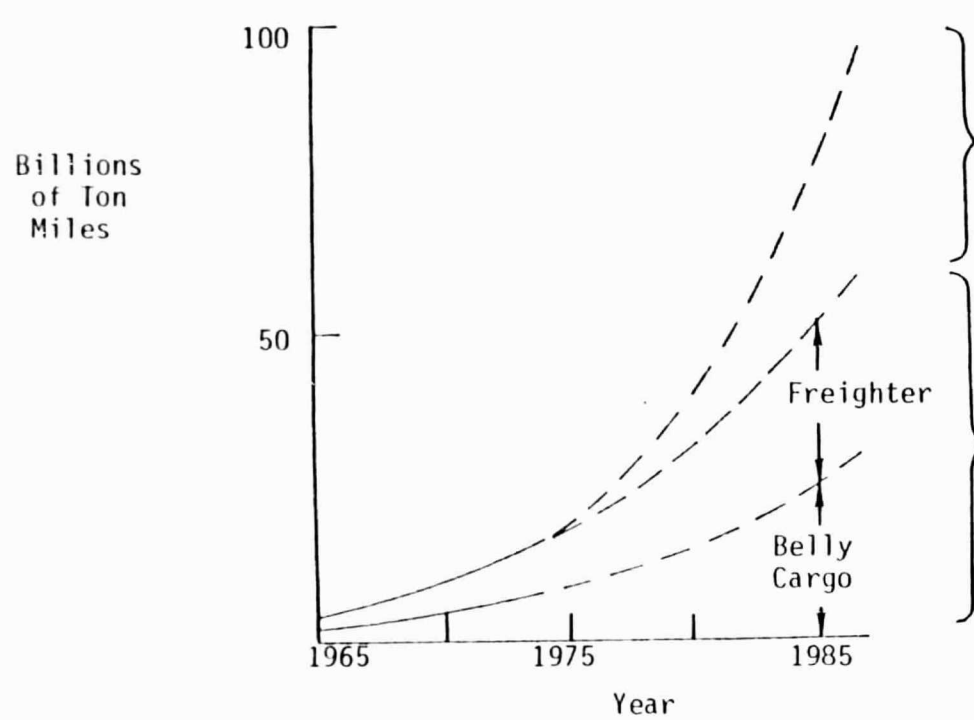


FIGURE 31

HISTORY AND FORECAST OF AIR CARGO GROWTH



NEW MARKET OBJECTIVE

- 16% Growth From 1975
- Additional Traffic Equivalent to 240 747 F's in 1985

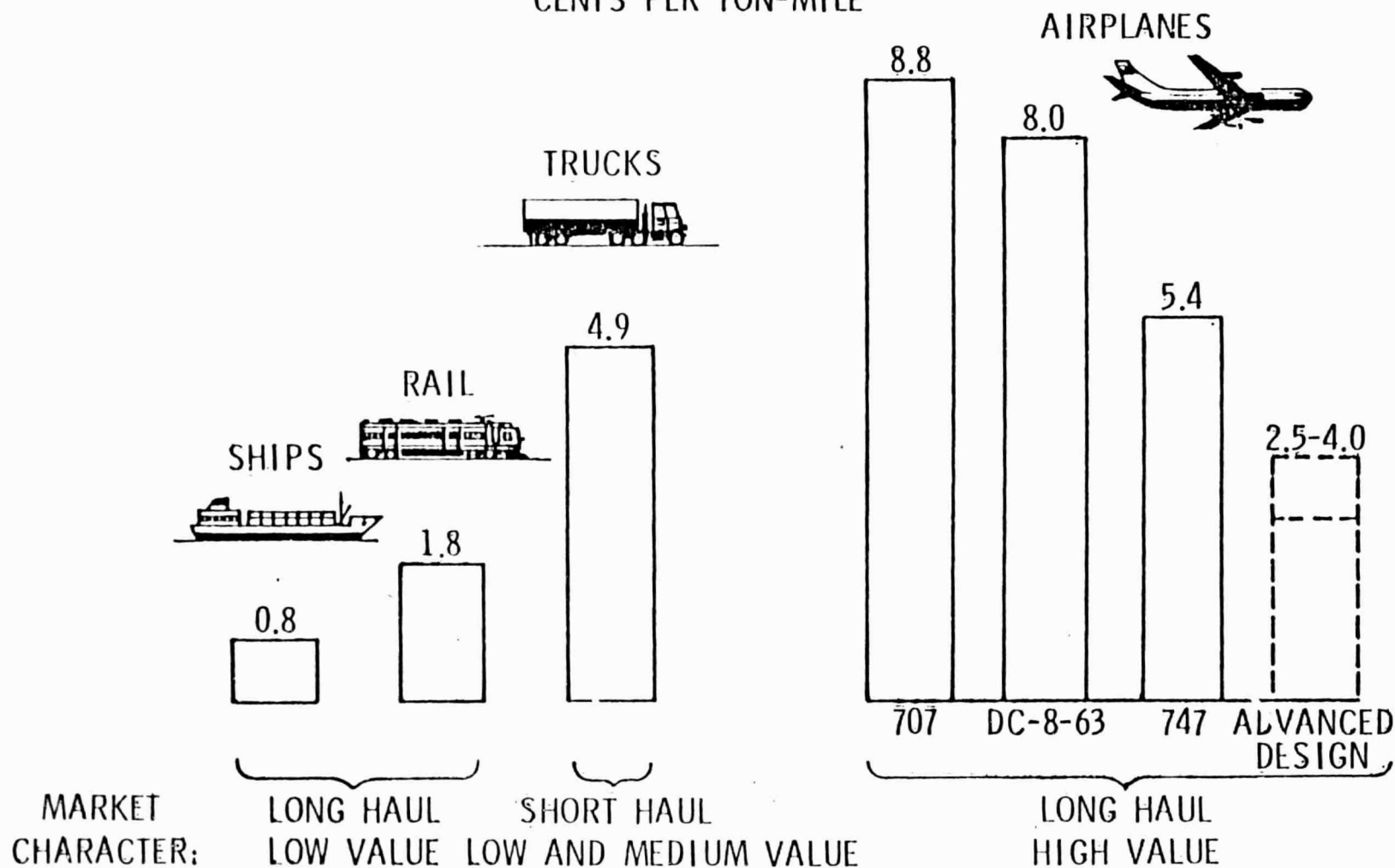
CURRENT MARKET

- 11% Growth From 1975

FIGURE 32

CARGO TRANSPORTATION OPERATING COSTS

CENTS PER TON-MILE

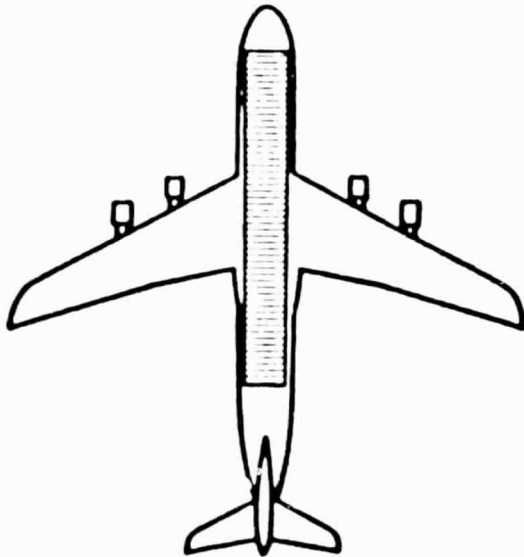


Source: The Future of the U.S. Domestic Air Freight Industry
Lewis Schneider, Harvard University 1973

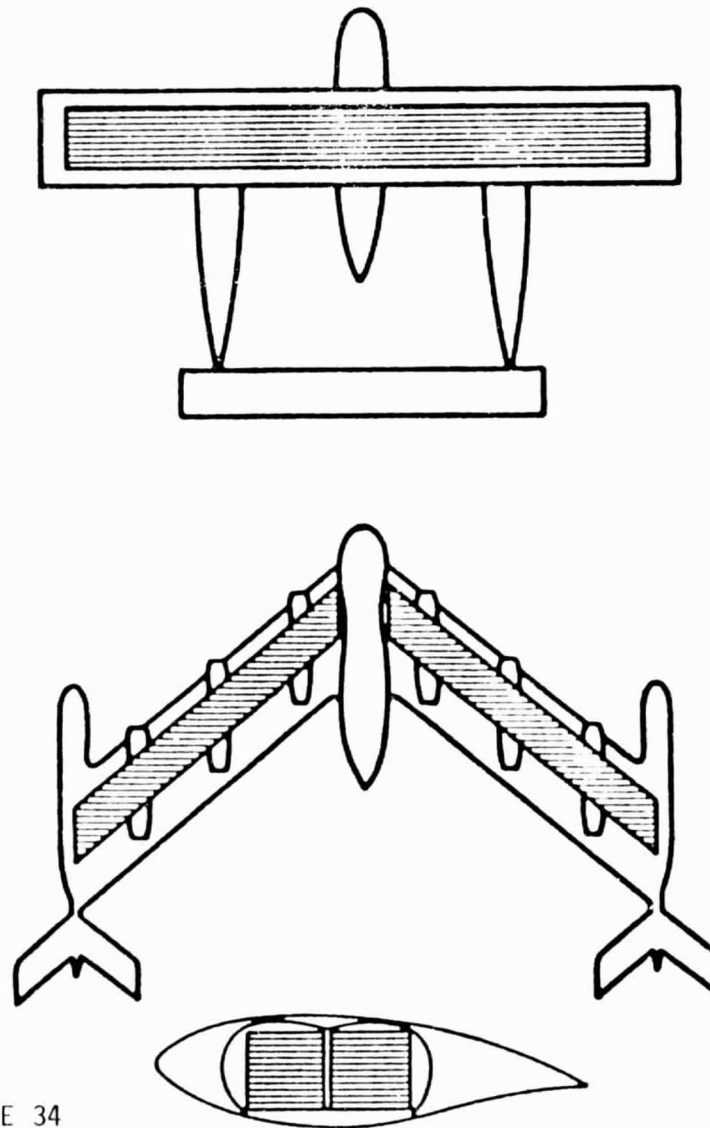
FIGURE 33

LOAD DISTRIBUTIONS FOR CARGO AIRCRAFT

CONVENTIONAL LOADING



SPAN-DISTRIBUTED LOADING



NASA RX75-2808
7-24-74

FIGURE 34

REPRESENTATIVE PAYLOAD AND FUEL EFFICIENCY OF AIR CARGO CONCEPTS

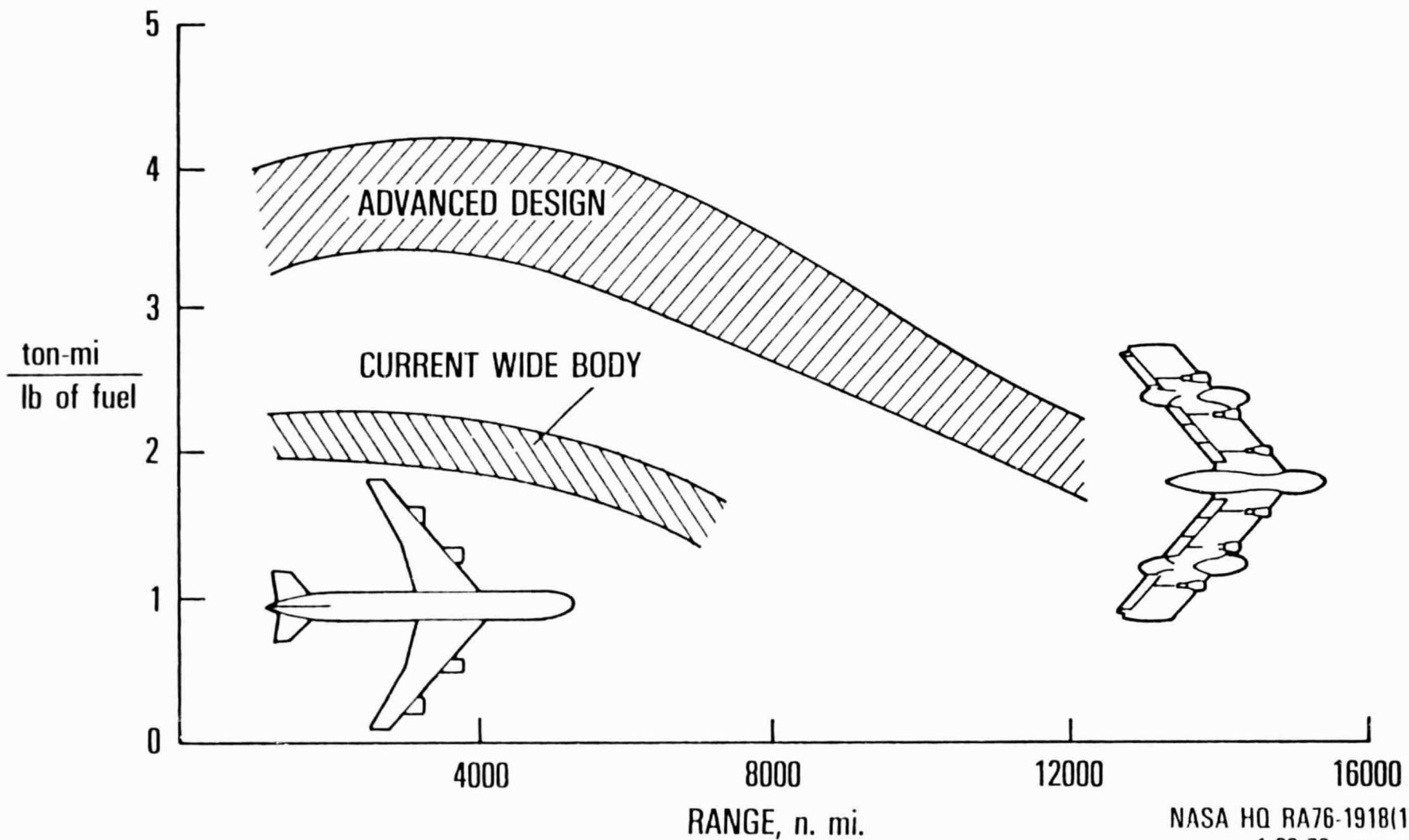
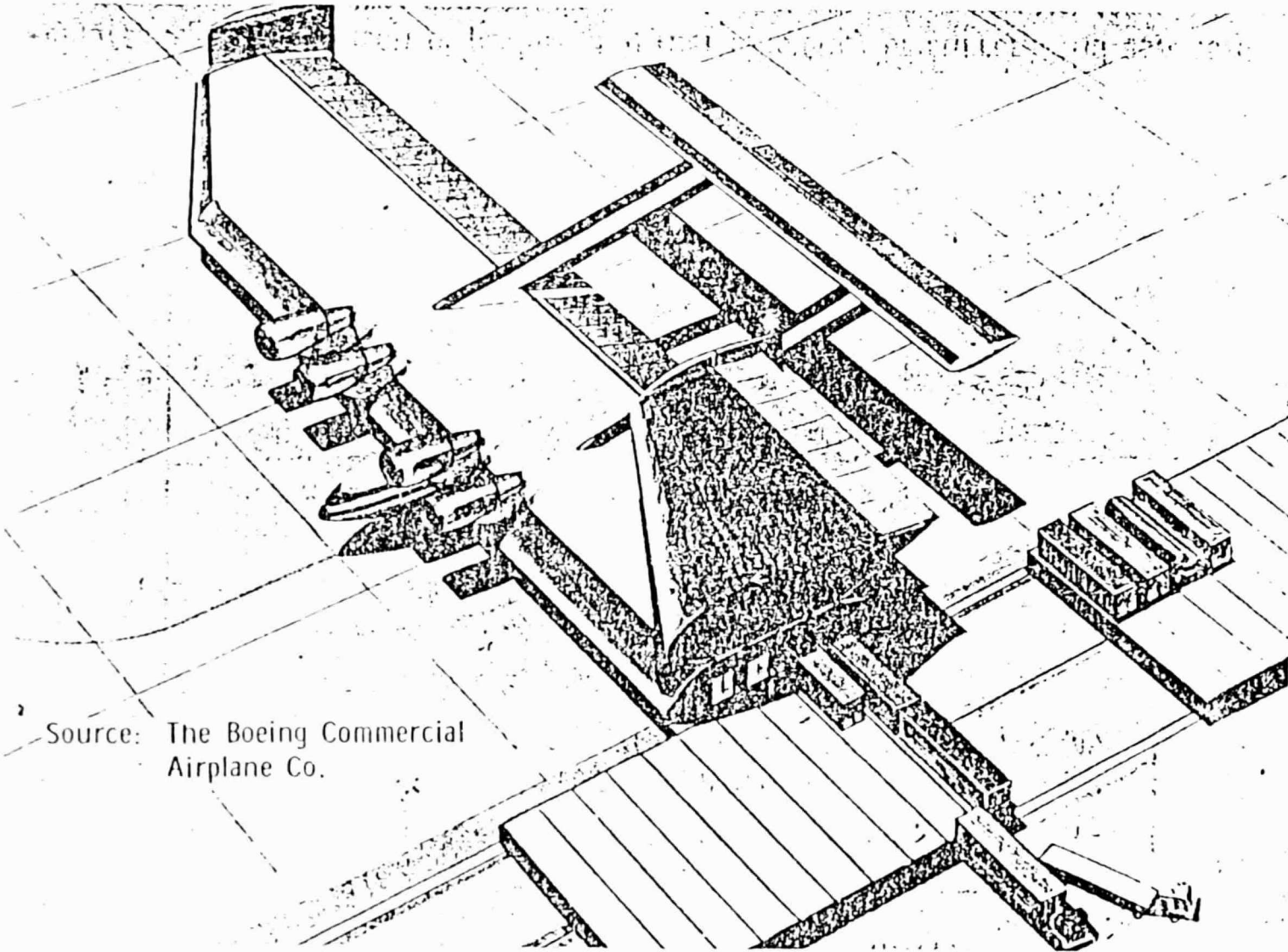


FIGURE 35

NASA HQ RA76-1918(1)
1-20-76

ILLUSTRATION OF MULTIMISSION FREIGHTER CONCEPT



Source: The Boeing Commercial Airplane Co.

FIGURE 36

CONCEPTUAL ILLUSTRATION OF A FUTURE AIR CARGO TERMINAL AREA SYSTEM

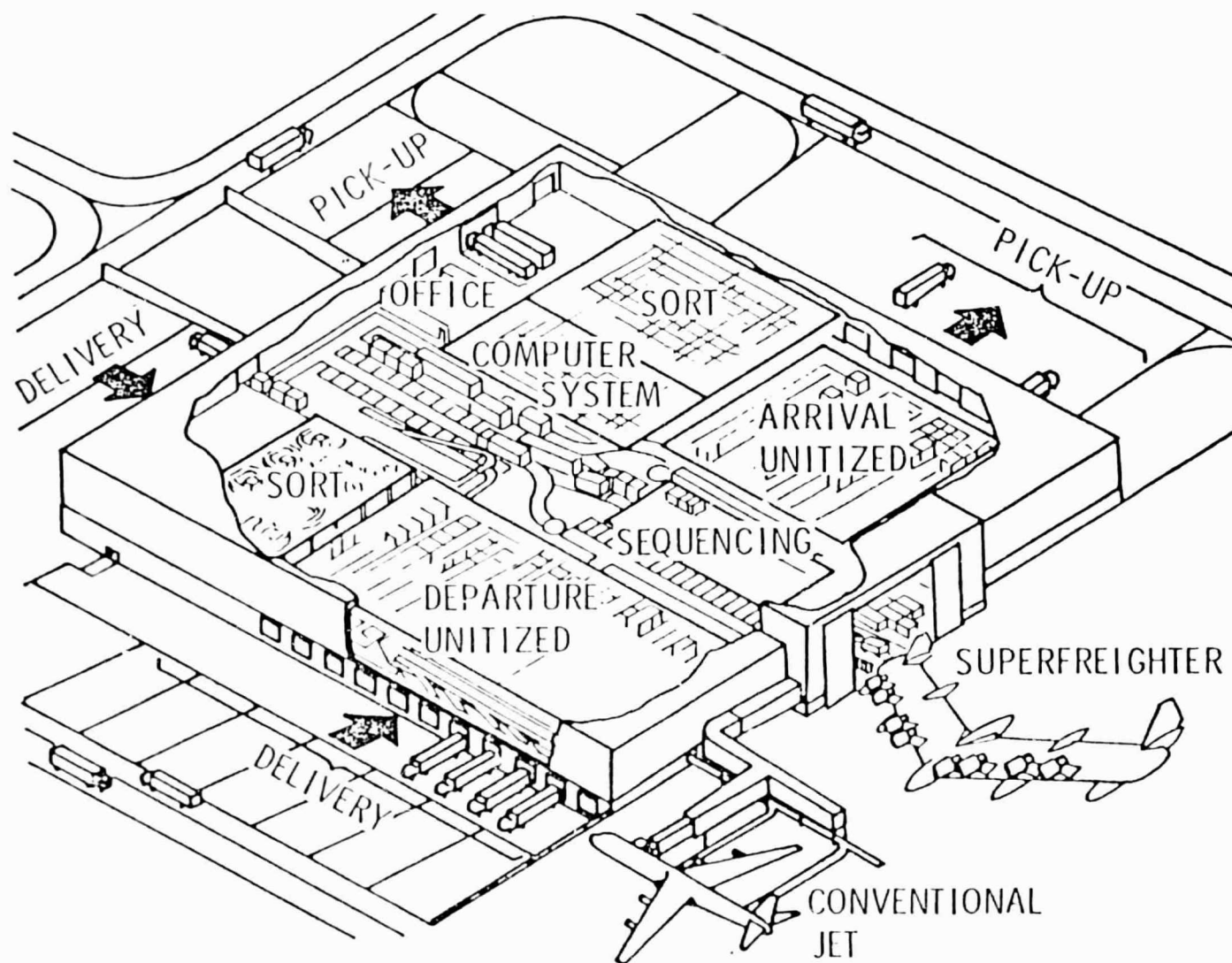
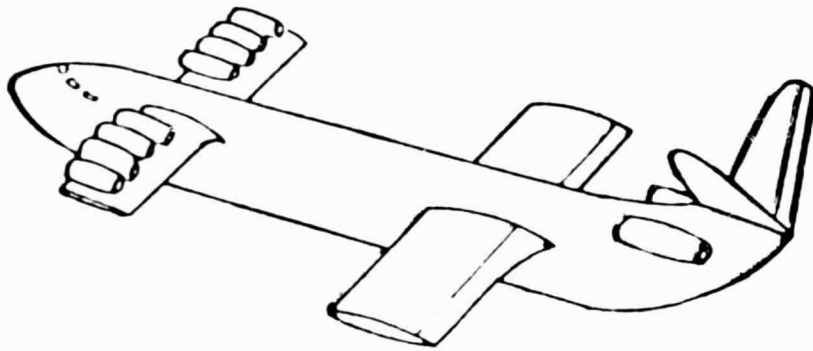


FIGURE 37

FOREIGN DEVELOPMENTS IN LARGE CARGO AIRCRAFT



SOVIET EKRANOPLAN

(Wing in Ground Effect-Wig)

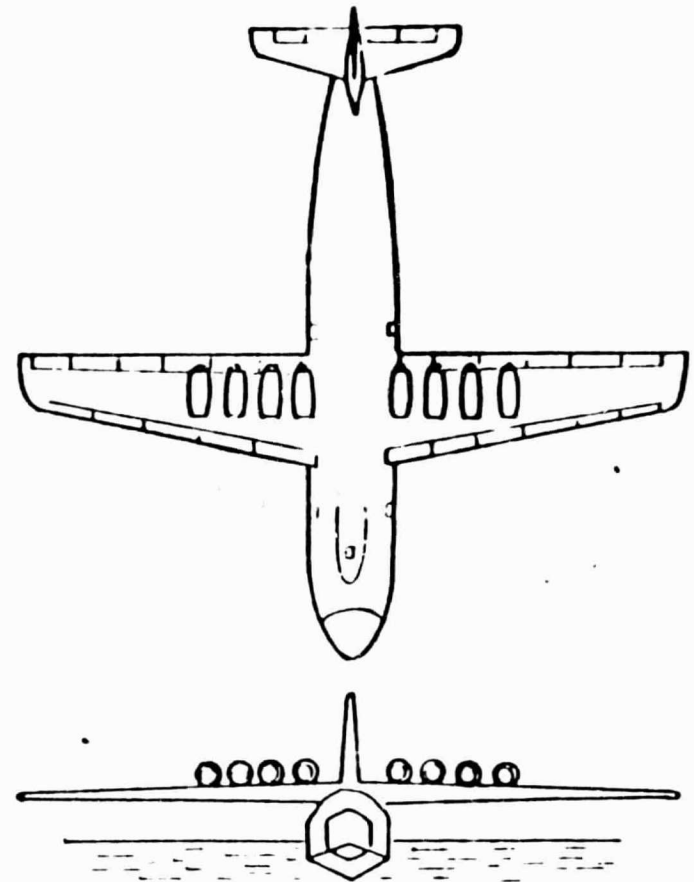
Span ~ 1125 ft

Length ~ 1125 ft

Speed ~ 300 knots

Operates at 25-50 ft over water

10 gas turbine engines



DORNIER FLYING SHIP

(Hose-Loading)

Span = 334 ft; Length = 340 ft

Speed = 440 kts; Range = 4000 n.mi.

Gross weight = 2.2 million pounds

FIGURE 38

INTERMOVAL CARGO TERMINAL

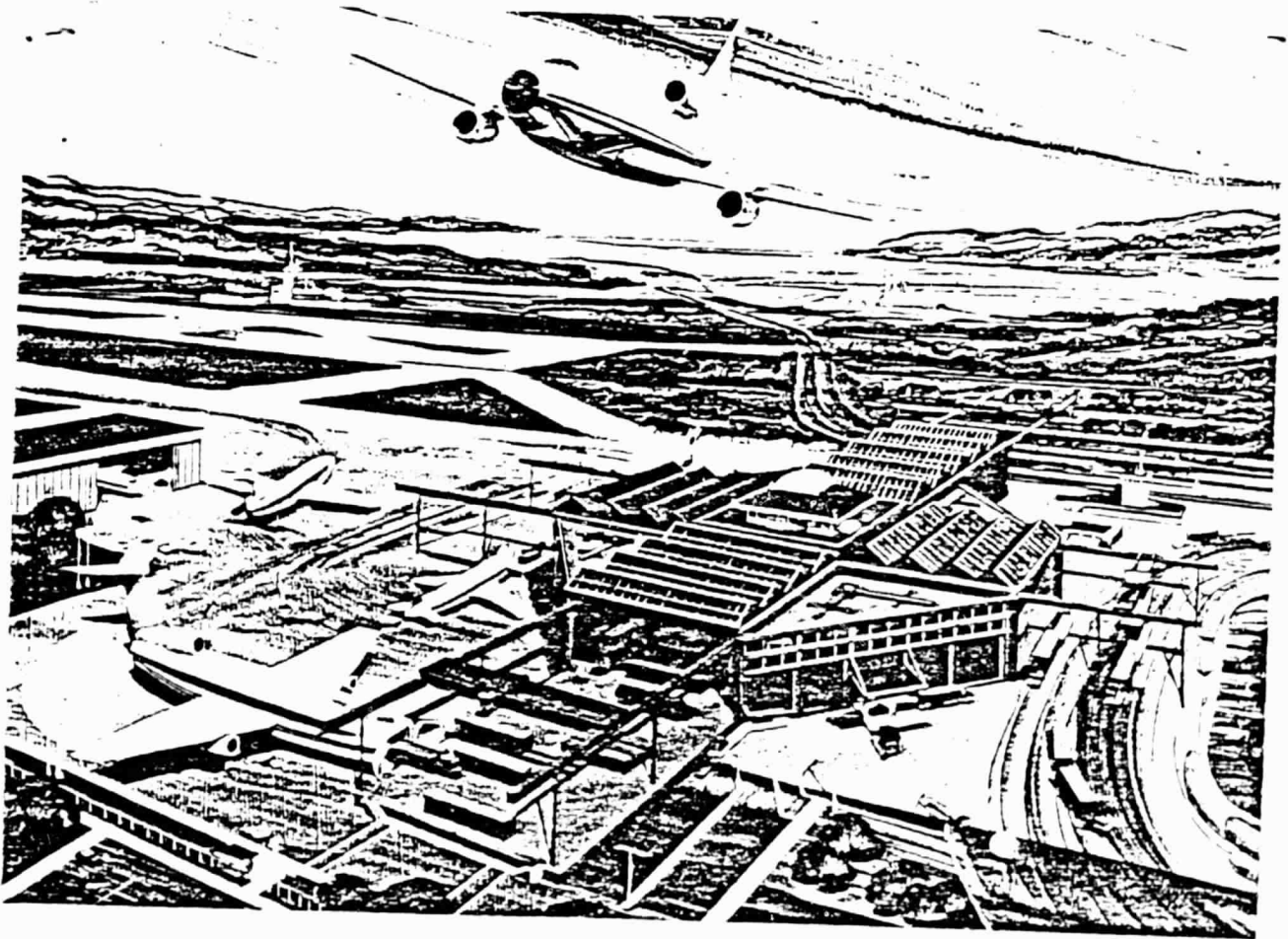


FIGURE 39

LIGHTER-THAN-AIR SHIP

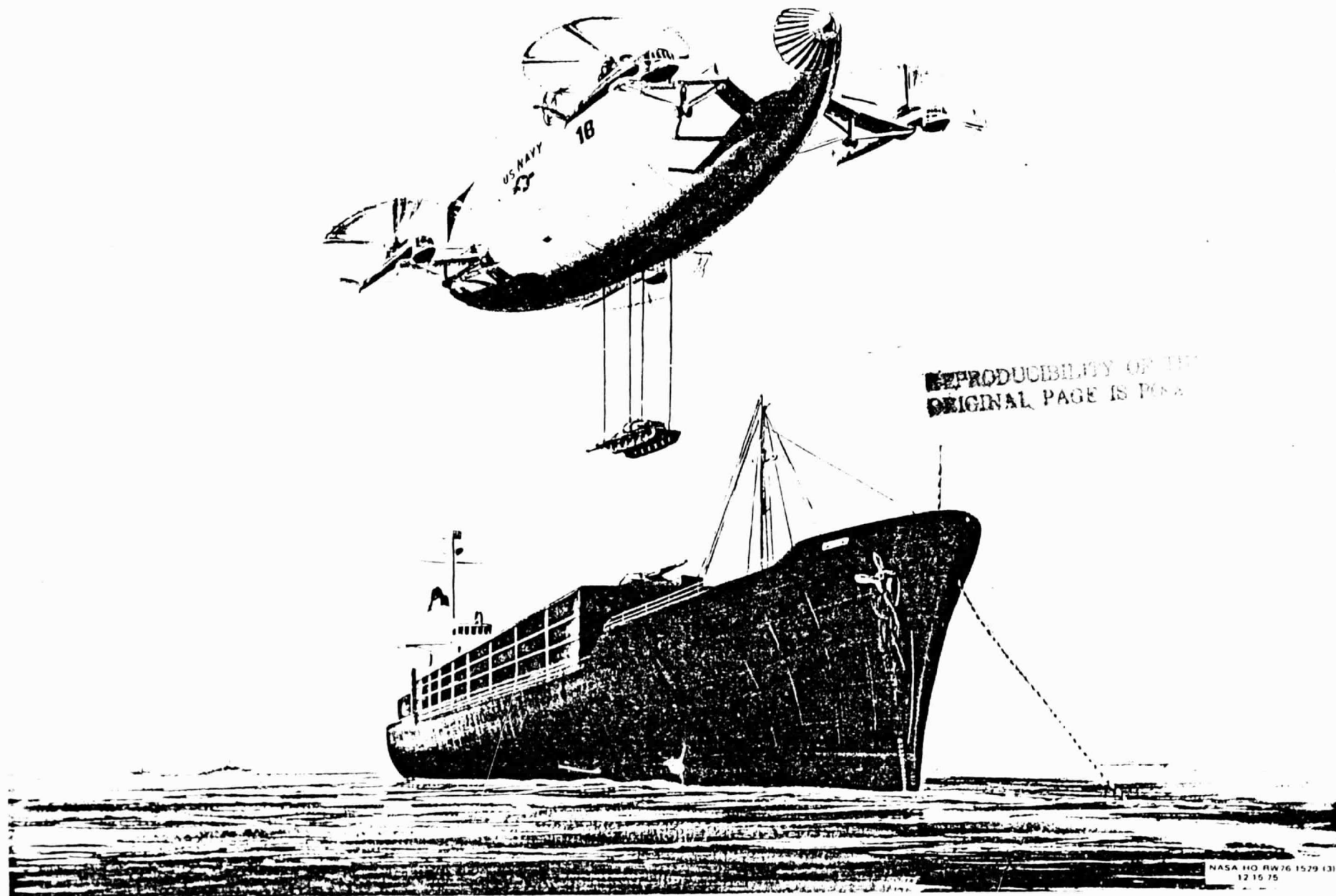
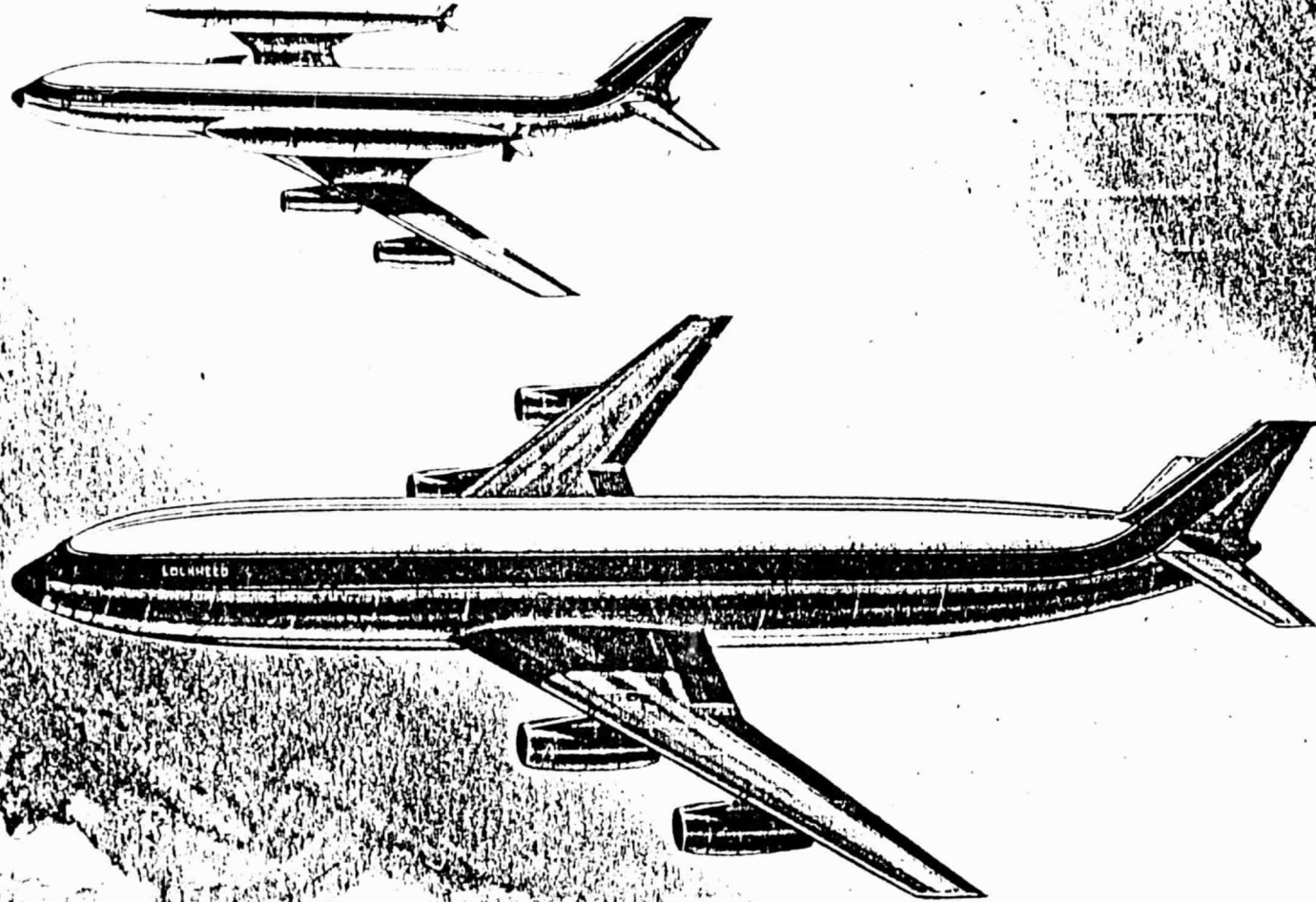


FIGURE 40

HYDROGEN FUELED SUBSONIC AIRCRAFT



C.G. Hansen

FIGURE 41

HYDROGEN FUELED SUPERSONIC AIRCRAFT

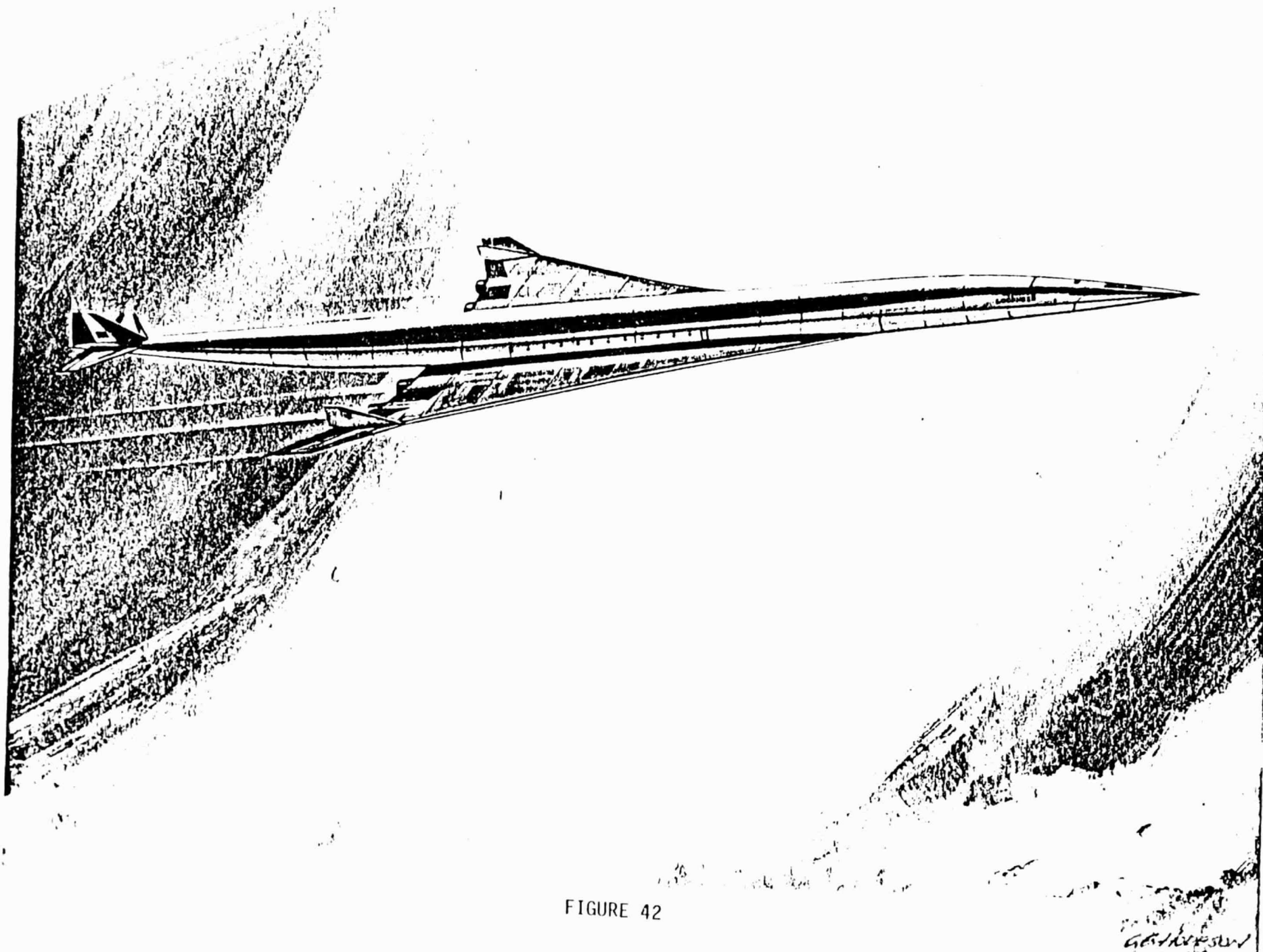


FIGURE 42

OUTLOOK FOR SHORT-HAUL AIRCRAFT
INCLUDING STOL AIRCRAFT POTENTIAL

VIEWGRAPH PRESENTATION

Prepared by:

Operations Research, Inc.
June 23, 1976

Operations Research, Inc.

VUGRAPHS— MAIN POINTS

1. World Transport Aircraft Market

There is a real and substantial future market, much of which is contested. Whether we like it or not, we have strong competitors. Will we meet this challenge?

2. Commercial Transport Aircraft

Provides projections of world market, plus high/low for U.S. Note that these are "independent" sources. Foreign competition is very real and increasingly strong.

3. Air Traffic on Stages Between 0-500 nm

Most of traffic (seat-miles) is short-haul with median of about 250 nm.

4. World-Wide Short-Range Commercial Transport Market

This is essentially a subset of total market, focusing on short-range portion. Same type of story—the market is projected to be there (Source: DMS).

5. Annual Deliveries of R/STOL Aircraft

Same as above, but narrowing down to R/STOL in particular (Source: Douglas).

6-8 Rebirth.....British Airways.....British Economist

Views expressed in 1973-74-75; all saying more about STOL and its potential application and use.

9. Japan Situation

Japan, in near term, not considering STOL, but what about early to mid-eighties? Note strong foreign competition.

10. DeHavilland Ad

This is a throw-in, but it demonstrates one major point: DHC is out there now both producing and selling STOL aircraft. Where will they be and where will we be in 10 years?

Operations Research, Inc.

11. Unique STOL Capabilities

Pictorial representation of application areas, based on unique STOL capabilities.

12-16 Enumerates application areas, one at a time.

17. Integrated Ground-Air Transportation

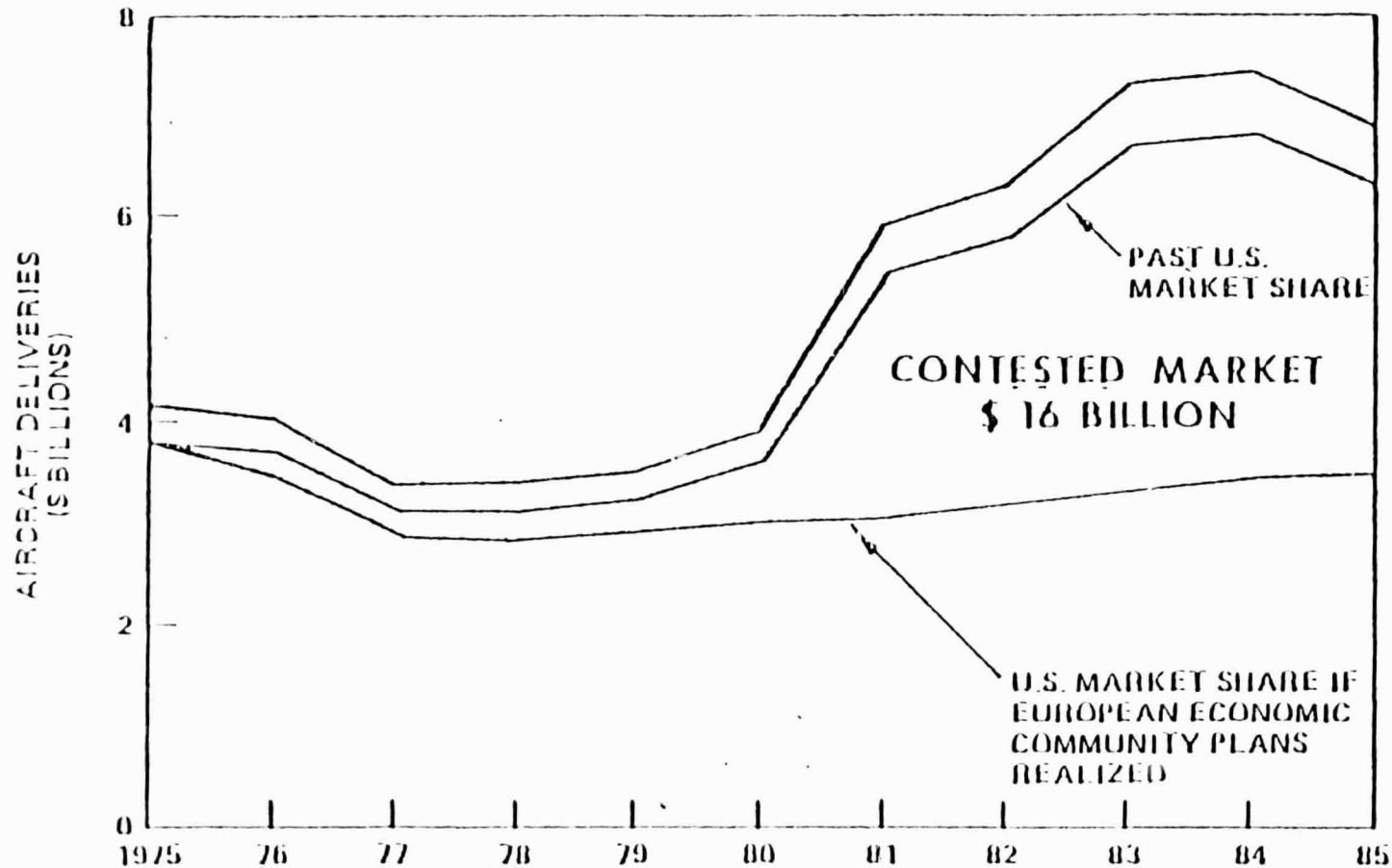
Shows 3-phase concept using STOL (from Douglas STOL and the L. A. Megalopolis).

18. Summary

Reiterates potential civil benefit areas.

WORLD TRANSPORT AIRCRAFT MARKET

TOTAL WORLD MARKET — 10 YEARS — \$ 52 BILLION



THERE WILL BE A LARGE WORLD DEMAND FOR
CIVIL AIRCRAFT

TABLE 3
COMMERCIAL TRANSPORT AIRCRAFT
Shipments 1976 - 1985
(1975 Constant Dollars in Billions)

	<u>WORLD MARKET</u>	<u>U.S. SHARE</u>			
		<u>HIGH</u>		<u>LOW</u>	
		<u>\$</u>	<u>%</u>	<u>\$</u>	<u>%</u>
AECMA ^{1/}	47.8	41.7	87.2	38.5	80.6
AIAA ^{2/}	54.4	49.5	91.0	46.2	85.0
BOEING ^{3/}	52.0	47.2	90.8	31.0	59.6
DOUGLAS ^{4/}	52.9				
EEC ^{5/}	53.4	46.4	86.9	37.2	69.6

^{1/} Commission of the European Communities, Action Programme for the Aeronautical Sector, Brussels, Oct. 1975

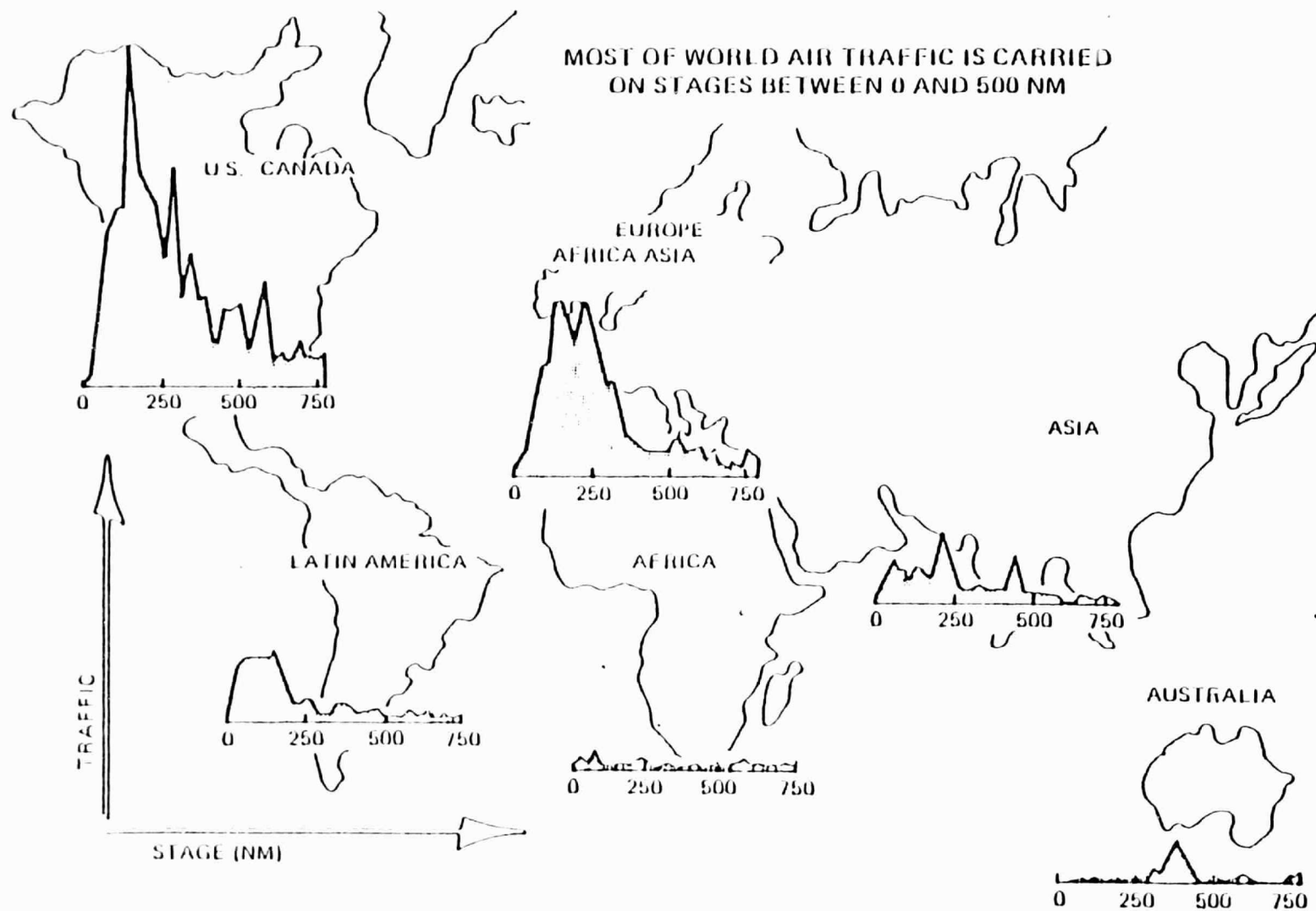
^{2/} The Challenge of Foreign Competition, Research Report, November 1975, AIAA

^{3/} Presentation by Boeing Commercial Airplane Company, Future of Aviation, National Transportation System, for the Subcommittee on Aviation and Transportation R&D, May 11, 1976. Data compiled from graph and are estimates only.

^{4/} Douglas Aircraft Company Report - C1-804-3672A, The Passenger Air Transport Market, 1975 - 1990, June 1975.

^{5/} Commission of the European Communities, op. cit.

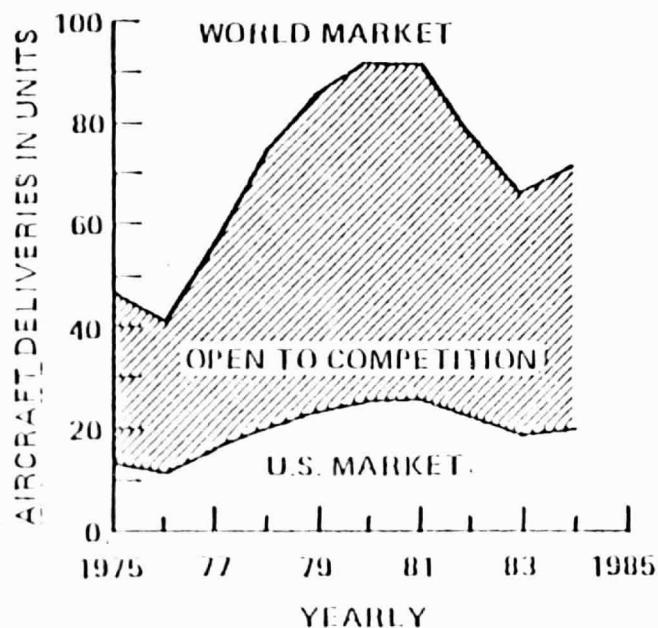
MOST OF WORLD AIR TRAFFIC IS CARRIED
ON STAGES BETWEEN 0 AND 500 NM



WORLDWIDE SHORT-RANGE COMMERCIAL TRANSPORT

MARKET POTENTIAL FOR STOL AIRCRAFT*

1975-1984



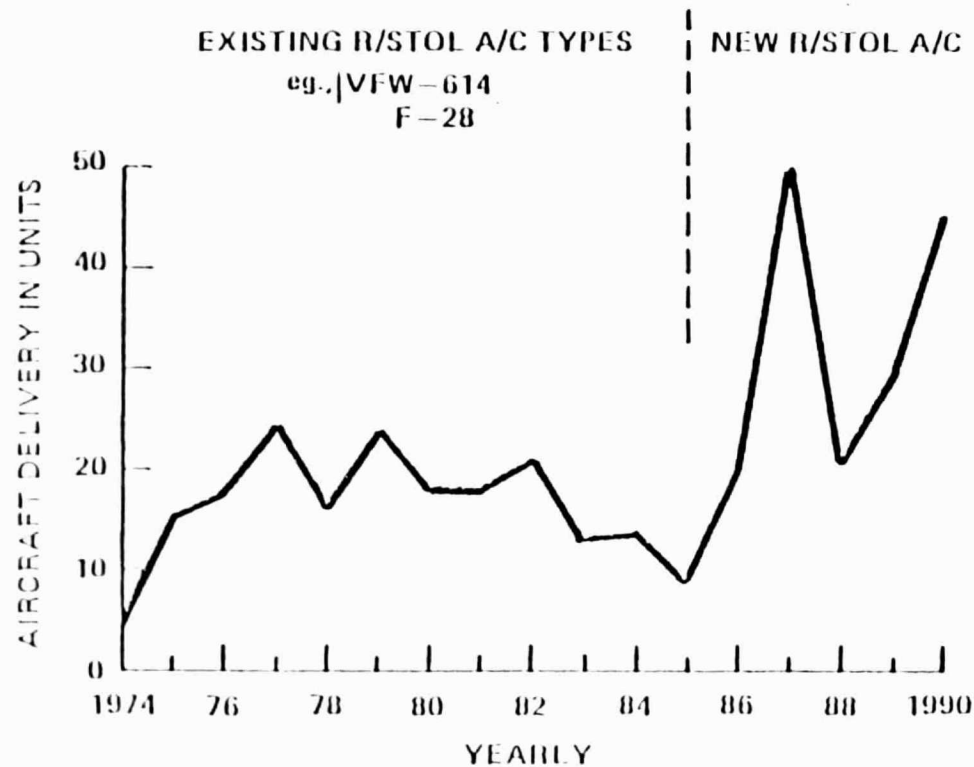
- STOL MARKET POTENTIAL IS 20 PERCENT OF ALL COMMERCIAL UNITS BUILT DURING 10 YEAR PERIOD, BUT ONLY 6.1 PERCENT OF DOLLAR VALUE
- 702 SHORT RANGE COMMERCIAL TRANSPORTS WILL BE BUILT THROUGH 1984 VALUED AT \$3.4 BILLION (1975 CONSTANT DOLLARS)
- DELIVERIES PEAK IN 1980 - 1981
- 73 PERCENT OF UNITS TO BE PRODUCED THROUGH 1984 ARE OPEN TO COMPETITION
- STOL PERFORMANCE WILL BE PREFERRED DURING THE FORECAST PERIOD
- NEW DESIGN WILL STRESS LOW NOISE AND EMISSION LEVELS

* EXCLUDES: USSR AND CHINA

SOURCE: WORLD AIRCRAFT FORECAST, DMS, INC., 1975

ANNUAL DELIVERIES OF R/STOL AIRCRAFT FORECAST FOR ICAO AIRLINES*

1975-1990



- A TURBINE POWERED AIRCRAFT TO SERVE SHORT HAUL ROUTES
- SEATING CAPACITY: 50-150 (ONE-CLASS)
- SEAT-MILE PRODUCTIVITY RANGE: 30-115 MILLION PER YEAR
- 355 STOL TYPE A/C FORECAST FOR DELIVERY BETWEEN 1974-1990
 - ⊙ 181 EXISTING STOL A/C, 1975-1984
 - ⊙ 174 NEW STOL A/C, 1985-1990
- FORECAST DELIVERIES VALUED AT APPROX. \$3.0 BILLION (1975 CONSTANT DOLLARS) BETWEEN 1975-1990
 - ⊙ EXISTING STOL A/C, 1975-1984, \$7 BILLION
 - ⊙ NEW STOL A/C, 1985-1990, \$2.3 BILLION
- DELIVERIES PEAK IN 1987 and 1990

*EXCLUDES: USSR AND CHINA

SOURCE: DOUGLAS AIRCRAFT COMPANY, THE PASSENGER AIR TRANSPORT MARKET, 1975-1990, JUNE 1975

THE REBIRTH OF THE STOL AIRCRAFT 1/

MILITARY FUNDS BOEING AND McDONNELL DOUGLAS FOR STOL
TRANSPORT PROTOTYPES

MEDIUM RANGE JET STOL TRANSPORT FOR MILITARY SHOULD NOT
BE HARD TO CONVERT TO CIVILIAN USE

THIS COULD ENABLE U.S. COMPANIES TO COMPETE WITH FOREIGN
AIRCRAFT MAKERS IN SHORT-HAUL AIRCRAFT MARKET LATE IN
THE 1970's

CHIEF COMPETITION FOR ANY COMMERCIAL VERSION OF THE AF
MEDIUM-RANGE STOL AIRCRAFT WILL PROBABLY BE A CONSORTIUM
OF SPANISH, WEST GERMAN, BRITISH AND SWEDISH AEROSPACE
COMPANIES

COMMENTS OF K. G. HARR, AIA PRESIDENT:

- MERITS OF RAPID AND EFFICIENT POINT-TO-POINT
CAPABILITIES OF STOLS ARE BEST UNDERSTOOD ABROAD
- WE HOPE NEED FOR SHORT-HAUL AIRCRAFT WILL NOT HAVE
TO BE MET ENTIRELY WITH FOREIGN-MADE AIRCRAFT
- OVER 30 PERCENT OF SHORT-HAUL PAX INCREASE BY 1986
WILL BE TRAVELLING ON ROUTES IDEALLY SUITED FOR STOLS

AEROPLANES FOR THE EIGHTIES
COMMENT BY BRITISH AIRWAYS 1/

- 0 BRITISH AIRWAYS' OPERATIONS IN 1988 WILL CALL FOR NINE DIFFERENT TYPES OF SUBSONIC PASSENGER AIRCRAFT.
- 0 THE FIRST CATEGORY DESCRIBES QUITE A LARGE FLEET OF AIRCRAFT (ABOUT 70) WITH LESS THAN 150 SEATS FOR OPERATION OVER RANGES UP TO 1,500 MILES. I FEEL FAIRLY CONFIDENT THAT THIS AIRCRAFT OUGHT TO HAVE RTOL CAPABILITY TO ENABLE IT TO OPERATE FROM RUNWAYS ABOUT 4,000 FEET LONG.
- 0 THE SECOND CATEGORY.....200 SEATS.....1,500 MILES... NEED ABOUT 70. IT MIGHT BE INTERESTING FOR THIS TYPE TO HAVE RTOL CAPABILITY TOO.

1/ S. WHEATCROFT, GROUP PLANNING DIRECTOR, BRITISH AIRWAYS, ASTRONAUTICS & AERONAUTICS, MARCH 1974.

A RECENT BRITISH VIEWPOINT ^{1/}

"OTHER EXPERIMENTS ARE AIMED AT IMPROVING AIRCRAFTS' PERFORMANCE ON TAKE-OFF AND LANDING.... THIS COULD BE VERY HELPFUL IN THE LARGE POTENTIAL, SHORT-RANGE BUSINESS TRAVEL MARKET, PARTICULARLY IN AMERICA AND EUROPE—WHERE THE NEED IS FOR FREQUENT SERVICES, FREQUENT STOPS AND AIRPORTS NEAR TOWN."

"IN THESE AIRPORTS, VERTICAL TAKE-OFF BY QUIET AIRCRAFT COULD BE IDEAL. BUT ... THERE IS MORE HOPE IN STOL."

^{1/} THE ECONOMIST, 24 APRIL 1976, P. 75.

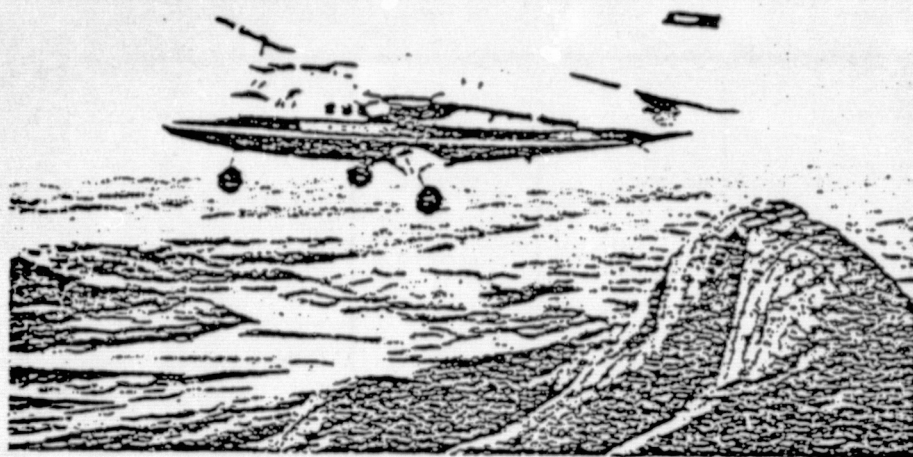
JAPAN SITUATION

CURRENT CONDITIONS

- 50 OF 70 AIRPORTS SERVED BY SCHEDULED AND NONSCHEDULED AIRLINERS HAVE RUNWAYS <5,000 FT
- MINISTRY OF TRANSPORT TRIED TO EXTEND SHORT RUNWAYS (FOR 737) BUT PLANS ABANDONED DUE TO LOCAL RESIDENT OPPOSITION AND RISING COST OF LAND
- AIRCRAFT ALTERNATIVES TO REPLACE YS-11'S INCLUDE:
 - VFW F.28 Mk 6000 J
 - DC-9-QSF
 - BAC 111 700

INFERENCES

- JAPAN HAS DEFINITE NEED FOR AIRCRAFT THAT CAN LAND ON RUNWAYS <5000 FT
- OTHER COUNTRIES HAVE SIMILAR RUNWAY LIMITATIONS
- INCREASING RUNWAY LENGTHS WILL BE MET WITH OPPOSITION
- THE QUESTION THEN IS IF AND HOW TO USE THESE SHORTER RUNWAYS AND ASSOCIATED FACILITIES
- SOME NEW AIRCRAFT COULD BE AVAILABLE WITH STRONG OVERSEAS COMPETITION
- CURRENT STOL AIRCRAFT AVAILABLE (I.E., DHC DASH 7) TOO SMALL AND SLOW TO SATISFY NEEDS
- IF A LARGER, QUIET, ECONOMICAL STOL AIRCRAFT WERE AVAILABLE NOW, IT WOULD FIND AN IMMEDIATE MARKET IN JAPAN AND IN OTHER COUNTRIES WITH SIMILAR NEEDS AND SITUATIONS



A report from the airline that has pioneered year-round scheduled STOL service north of the Arctic Circle:

"Crews and passengers alike are totally enthused about our Twin Otters. Their reliability has been almost perfect...under conditions that are almost impossible."

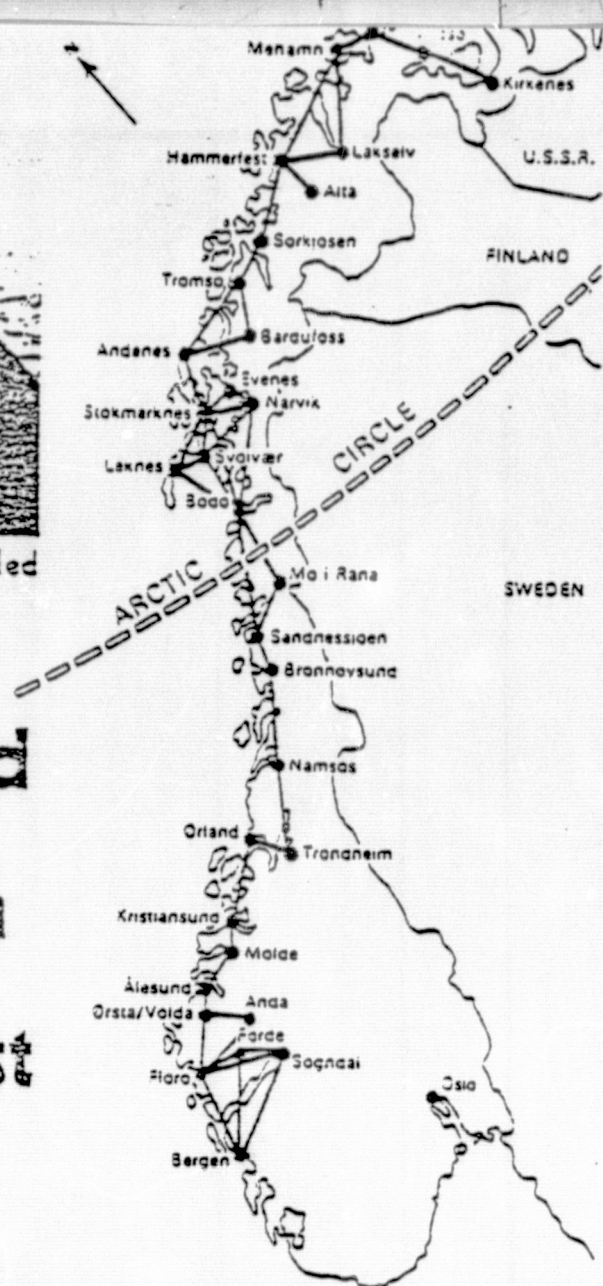
The network of Widerøe's Flyveselskap A/S stretches farther than the distance from London to Rome. But half of it is above the Arctic Circle. Virtually all of it lies along the mountainous, windswept coast of Norway. And most of its 32 airports just have single 800 m strips.

What a place to find one of the world's most dependable airline operations!

"Phase 1 of our network began in 1968 with our first Twin Otter flying 13½ hours a day, 6 days a week, on the segment between Bodø and Trondheim," reports Knut Schiemff-Larsen, marketing manager of Widerøe's. "In an entire year, we had only a single one-hour delay for technical reasons. And the only flight cancellations due to weather were in a 3-day period when a severe snowstorm buried every airport."

"Now we're using 10 Twin Otters... from Bergen all the way to Hammerfest, the northernmost city in the world... and east from there to Kirkenes on the Russian border. Annual utilization is about 2,400 hours per plane—and their reliability continues to be outstanding."

And the human side of Widerøe's operations is just as impressive.



When winding mountain roads and the stormy Norwegian Sea were the only links between the communities Widerøe's now serves, many were becoming depopulated. All felt estranged from other parts of Norway.

Now—what a change! Fine hospitals are minutes away instead of hours. Businessmen can get spare parts or materials the day they order them. The towns are growing again. New industries are springing up. It's easier to hire good teachers. Tourism is developing like never before. And there's a whole new optimism in the air—that literally came by air.

As for Widerøe's, it is looking forward to using the 50-passenger DASH 7 as traffic grows, particularly north of the Arctic Circle—because it knows what to expect from de Havilland in the way of performance. *The de Havilland Aircraft of Canada Limited, Downsview, Ontario M3K 1Y5. Telephone (+16) 633-7310. Telex: 0622128. Cable: Moth, Toronto.*

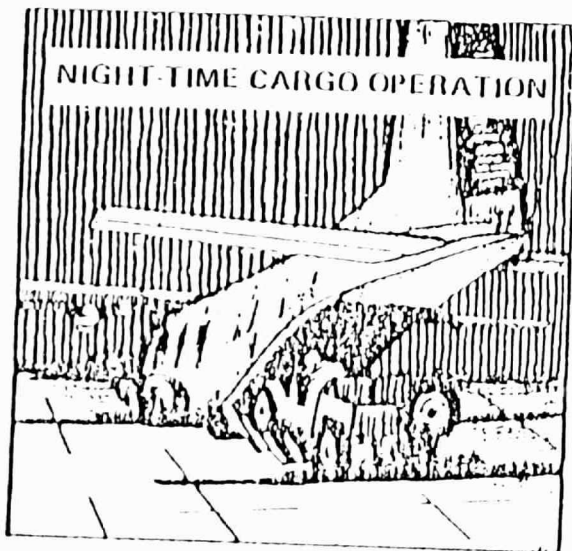
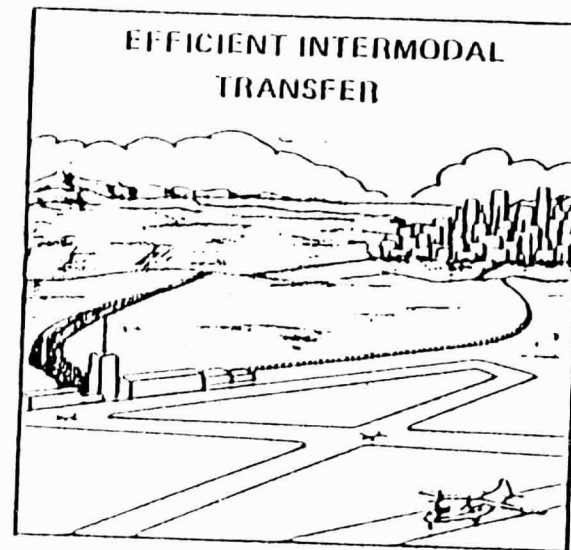
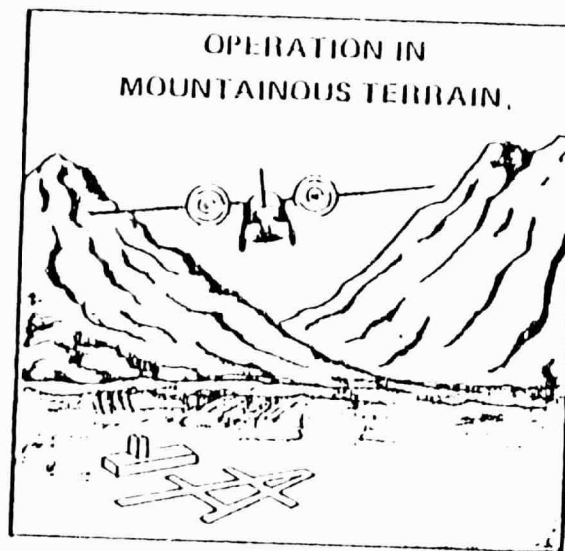
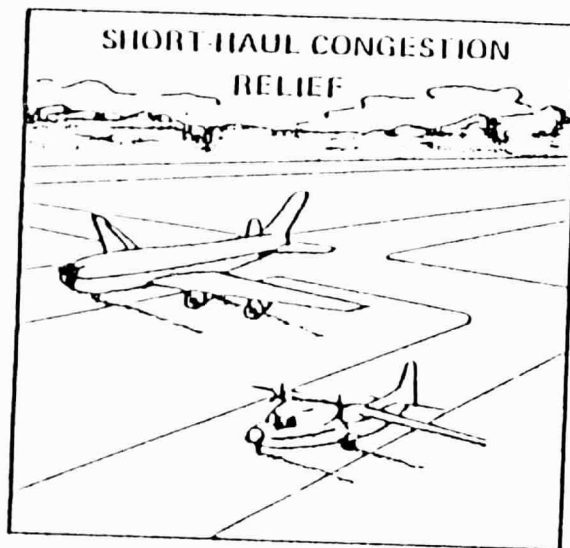
Twin Otter: the standard of dependability and profitability in 50 countries.

de Havilland

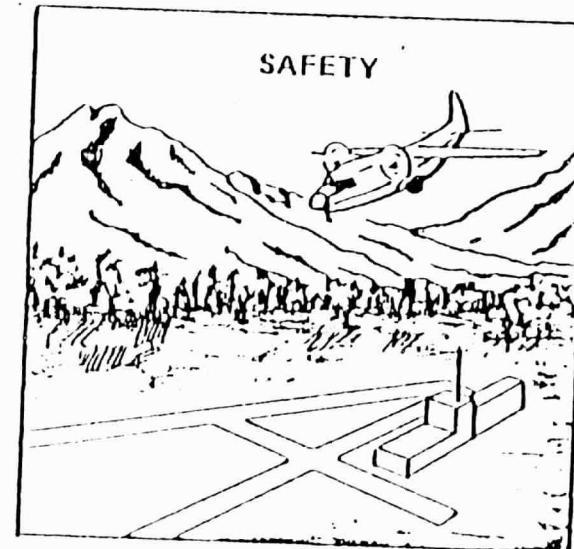
REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

UNIQUE STOL CAPABILITIES

CIVIL DOMESTIC/FOREIGN APPLICATIONS



- REDUCED NOISE
- SHORT RUNWAY CAPABILITY
- HIGH ASCENT/DECENT ANGLE CAPABILITY



SHORT-HAUL CONGESTION RELIEF

- 0 LOW NOISE PROVIDES ACCEPTABLE HIGH DENSITY ALTERNATIVE
- 0 PARALLEL STOL RUNWAY OPERATIONS AT MAJOR AIRPORTS
- 0 REMOVAL OF TRAFFIC FROM MAJOR AIRPORT TO SUBURBAN RELIEVER

NIGHT-TIME CARGO OPERATIONS

- LOW NOISE COULD ALLOW NIGHT-TIME OPERATION
- INCREASE FACILITY AND AIRCRAFT UTILIZATION
- RELATES TO CONGESTION RELIEF BY SPREADING OPERATIONS OVER LONG TIME FRAME
- FACILITATES GROWTH IN AIR CARGO FOR UNIQUE APPLICATIONS
 - HIGH VALUE ITEMS
 - FAST MOVING; LOW BULK
 - PERISHABLES

OPERATION IN MOUNTAINOUS TERRAIN

- SUITED TO SELECTED U.S. AIRPORTS— MEDIUM AND LOW DENSITY
- PARTICULAR APPLICATIONS OVERSEAS
 - EUROPEAN COUNTRIES
 - JAPAN
 - SOUTH AMERICA
- FEW ALTERNATIVES IF NEW REGIONS ARE TO BE DEVELOPED

EFFICIENT INTERMODAL TRANSFER

- INTERMODAL TRANSFER ALONG RADIALS OUTSIDE CBD
 - TRUCK
 - RAIL
 - AUTO/BUS
- OPERATION AT POINTS OF MAJOR CARGO TRANSFER

· SAFETY

- 0 SAFETY MARGIN AT LONGER RUNWAYS
- 0 GREATER CLEARANCES FOR ASCENT/DESCENT
- 0 OPERATIONS IN MOUNTAINOUS TERRAIN
- 0 ALTERNATIVES FOR SHORT RUNWAY-- HIGH ALTITUDE AIRPORTS

INTEGRATED GROUND-AIR TRANSPORTATION

1975 - 1990

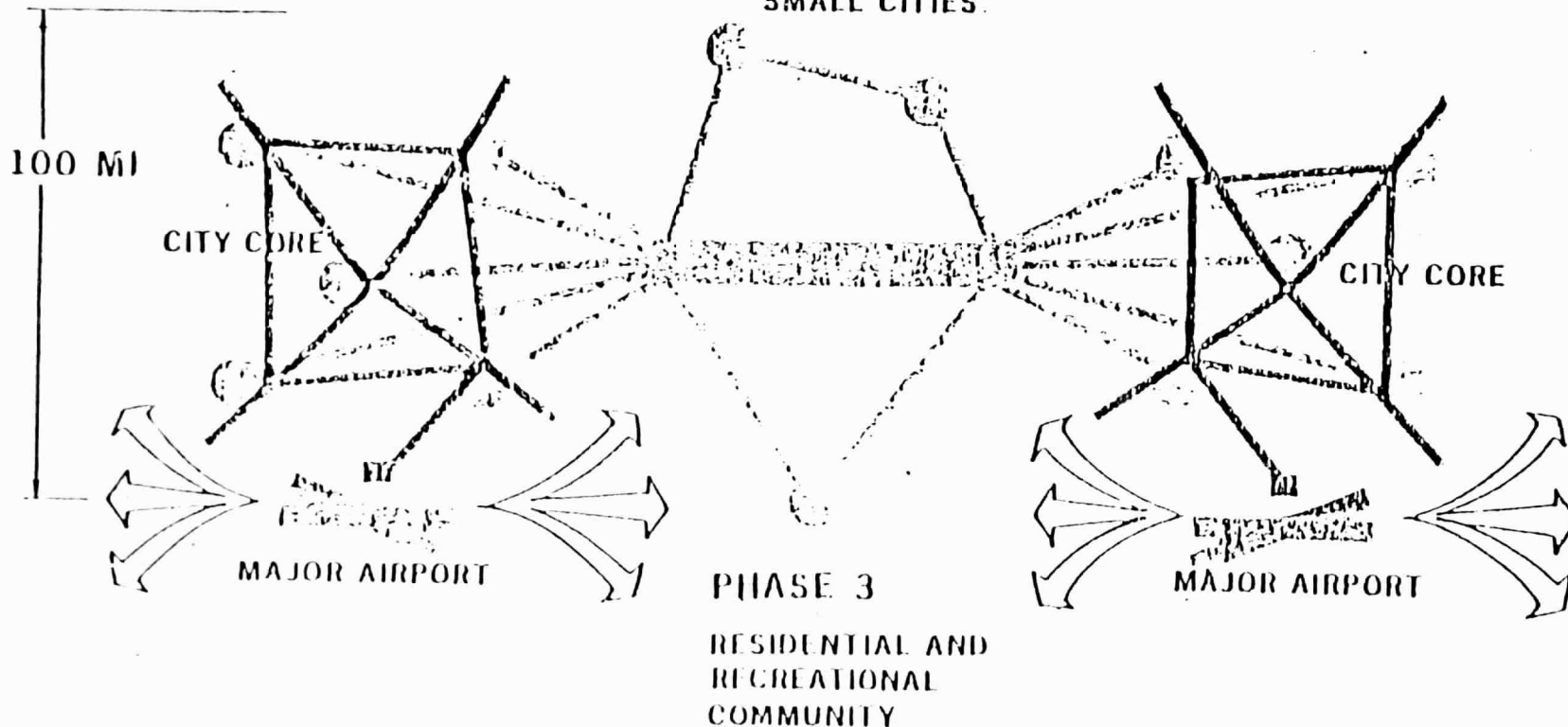
PHASE 1

MEGALOPOLIS TO
MEGALOPOLIS
200 TO 500 MI

PHASE 2

LOCAL SERVICE
SMALL CITIES.

 RAPID TRANSIT
 FIXED WING AIRCRAFT
 EXPRESS STOL ROUTES
 STOL PORTS



SUMMARY

POTENTIAL CIVIL BENEFITS OF STOL TECHNOLOGY

- 0 FOREIGN/DOMESTIC MARKETS
- 0 DECREASE NOISE IMPACTS
- 0 RELIEVE AIRPORT CONGESTION
- 0 REDUCE ACCESS TIME
- 0 REDUCE LAND ACQUISITION
- 0 INCREASE SAFETY MARGINS
- 0 UNIQUE APPLICATION AREAS
- 0 IMPROVE OVERALL PRODUCTIVITY

SUPERSONIC AIRCRAFT
FORECAST OF WORLD FLEET SIZE
BY YEAR 2000

PREPARED BY:

OPERATIONS RESEARCH, INC.
JULY 2, 1976

LIST OF ILLUSTRATIONS

Table

1	Forecasts of World Supersonic Fleet Size by Year 2000	3
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Figure

1	Forecasts of World Supersonic Fleet Size by Year 2000	4
2	Forecasts of World Supersonic Fleet Size by Year 2000 - Douglas Forecast.	5
3	Forecast of World Supersonic Fleet Size by Year 2000 - Delphi Forecast	6
4	Economic Impact of One Supersonic Aircraft	7
5	Economic Impact of Contested Market for Supersonic Aircraft	8

INTRODUCTION AND SUMMARY

INTRODUCTION

This report covers forecasts of the world supersonic fleet size by the year 2000. Deliveries and fleet size are considered to be the same since none of the supersonic fleet will be retired during the period covered by the report. Six separate estimates are used in this report and show, where available, both an "upper limit" with no production constraints and a "most likely" number of aircraft based on production constraints. Most of the data used was obtained from the CIAP Monograph 2, September 1975. The Delphi forecast is based on an average of the responses of 34 individual experts in the major airlines, aerospace industries, national and international regulatory agencies, government and private research agencies, and in aviation publications. Contested market data is available only in the Delphi forecast and only for the year 1990. This data was extended to year 2000 by assuming that the percent of market shares would be the same in year 2000 as in year 1990.

SUMMARY

As shown in Table 1, forecasted data is only at certain points in time, primarily, the year 1990 and the year 2000. Most of the projections assume that the U.S. supersonic aircraft would not go into service until 1985. It is more likely that no advanced U.S. supersonic aircraft will go into service before the late 1980's or early 1990's. ^{1/}

Of the forecasts made, it appears that the Douglas forecast of 330 and the Delphi forecast of 225 for U.S. supersonics adjusted to 340 for world production (see Figure 1) are the most likely to be attained by the year 2000.

The data in Figure 2 was developed from a 1973 Douglas forecast that appears in CIAP Monograph 3 which estimates that there could be 131 supersonic aircraft in service in 1980, 250 in service in 1990, and 330 in service by 2000. Also shown is a Douglas forecast made in 1975 which shows 18 supersonic aircraft in service by 1978 (this number is adjusted to 16 since production on the Concorde stops at 16) and 99 in service by 1990.

Figure 3 is the Delphi forecast which shows both U.S. production and world production of supersonic aircraft by 1990 and U.S. production by 2000. Also shown is an interpolation of world production by 2000 assuming the U.S. share of the market in 2000 is the same as the U.S. share of the market will be in 1990 (66.0 percent). Also shown is a contested market of 115 supersonic aircraft which would have a \$28.3 billion (1975 constant dollars) on the GNP.

Figure 4 shows that the economic impact of one supersonic aircraft sold for \$90 million (1975 dollars) would add \$245.7 million to the U.S. GNP, provide 3800 aerospace jobs, 2350 jobs in supporting industry and 10850 service type jobs elsewhere in the rest of the economy for a total of 17,000 jobs. It would also benefit the U.S. economy by providing \$28 million in State/local taxes and \$49 million in Federal taxes that can be used as the government's contribution to enhance the supersonic or other aerospace programs. It will also make a major contribution to a favorable trade balance - U.S. as an exporter rather than an importer of supersonic aircraft.

^{1/} See: Aviation Daily, 6/14/76, p. 239 and Astronautics and Aeronautics, June 1976, p. 23

The scale in Figure 5 can be used to instantaneously determine the impact on the U.S. economy for up to 600 supersonic aircraft.

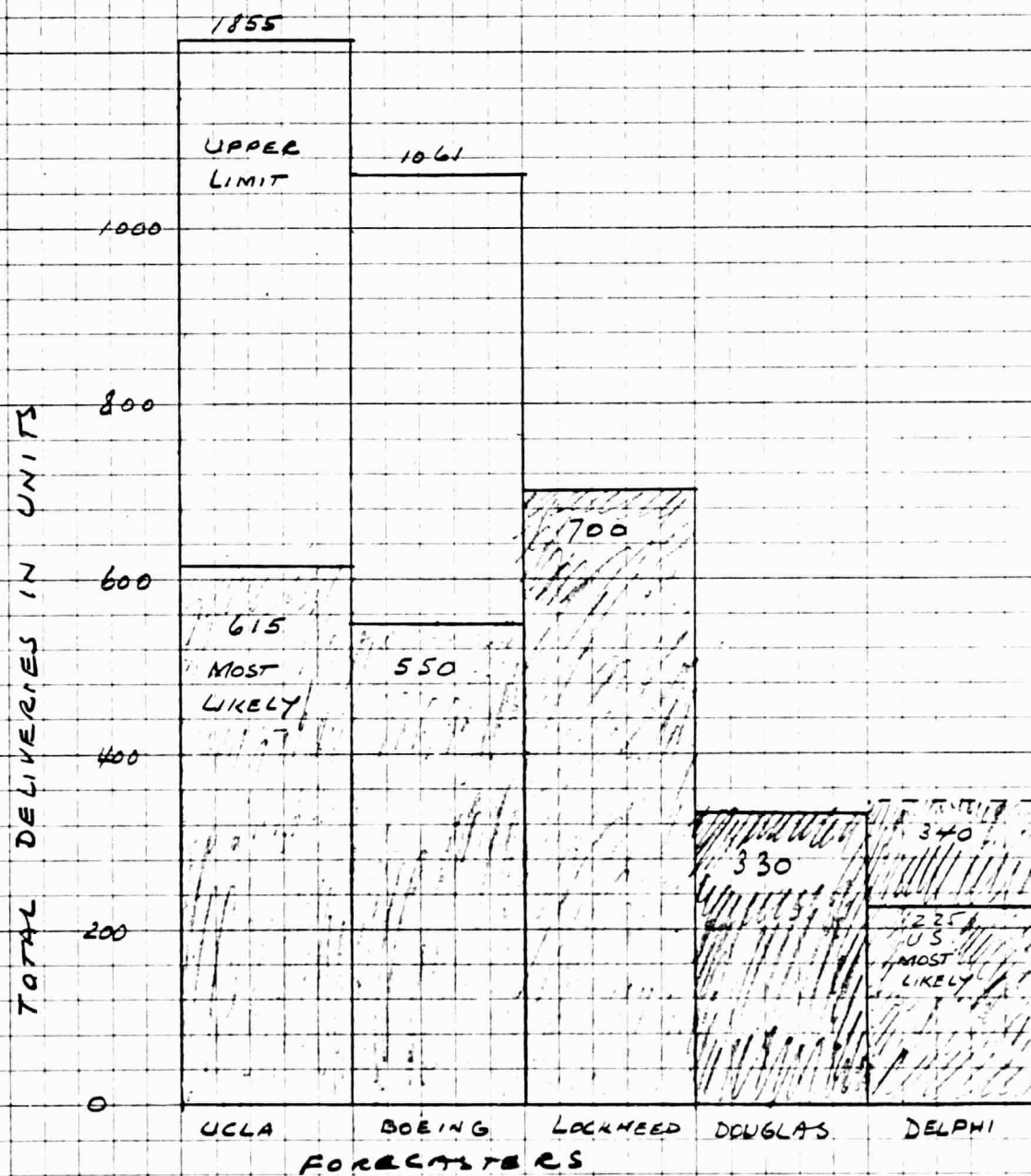
TABLE 1
FORECAST OF WORLD SUPERSONIC FLEET SIZE BY YEAR 2000

Year	Douglas		Boeing	Lockheed	UCLA	Delphi	
	1975 est	1973 est				U.S.	World
<u>1980</u>							
Upper Limit			330		51		
Most Likely	18	131			42		
<u>1985</u>							
Upper Limit							
Most Likely	20						
<u>1990</u>							
Upper Limit		250	800		440		580
Most Likely	101		200	300	241	165	250
<u>2000</u>							
Upper Limit			1061		1855		
Most Likely		330	550	700	615	225	

FIGURE 1

FORECASTS OF WORLD SUPERSONIC FLEET SIZE

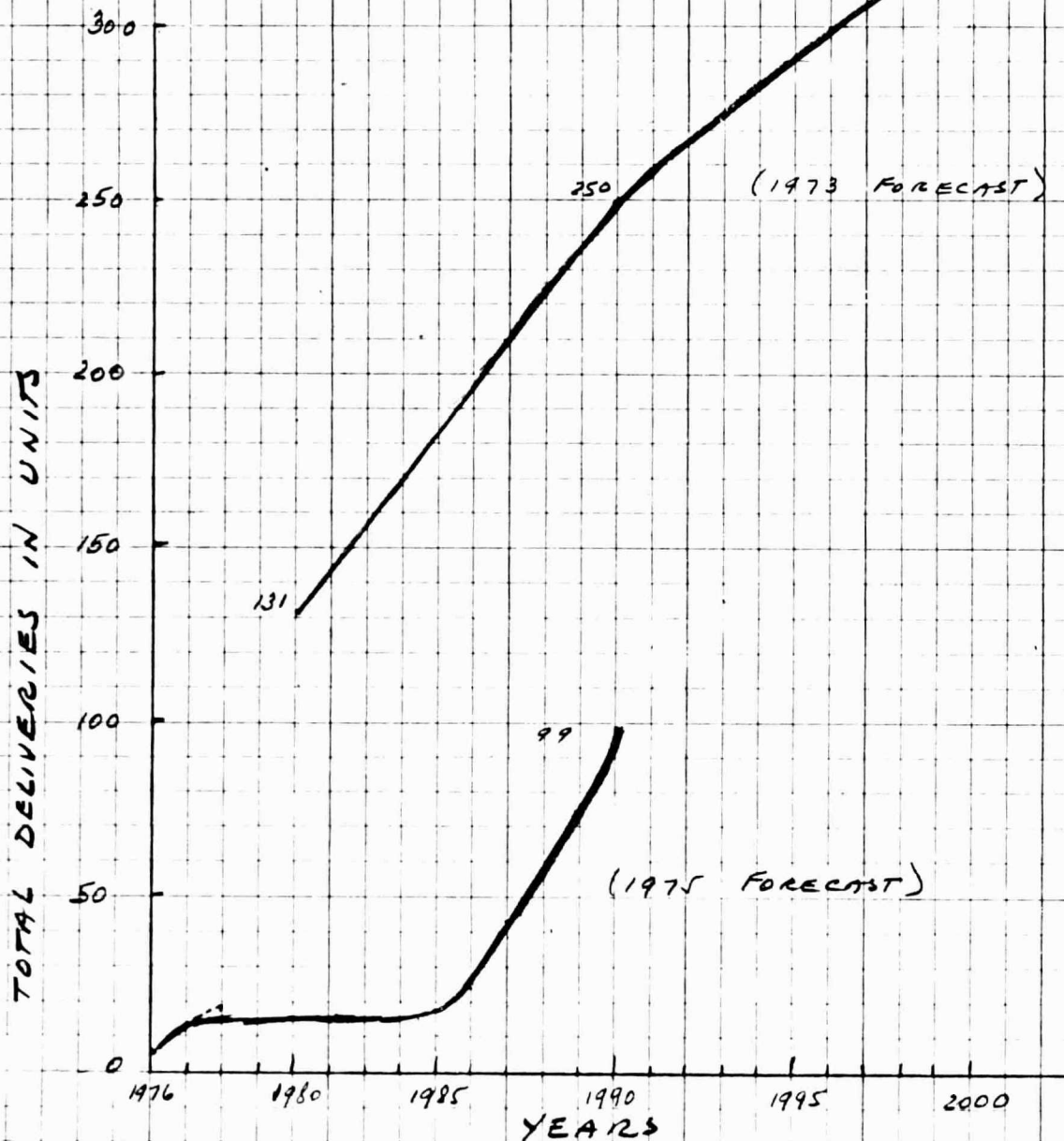
BY YEAR 2000



SOURCE: C.I.A.P. MONOGRAPH 2, SEPT. 1975 p. 8-70

FIGURE 2

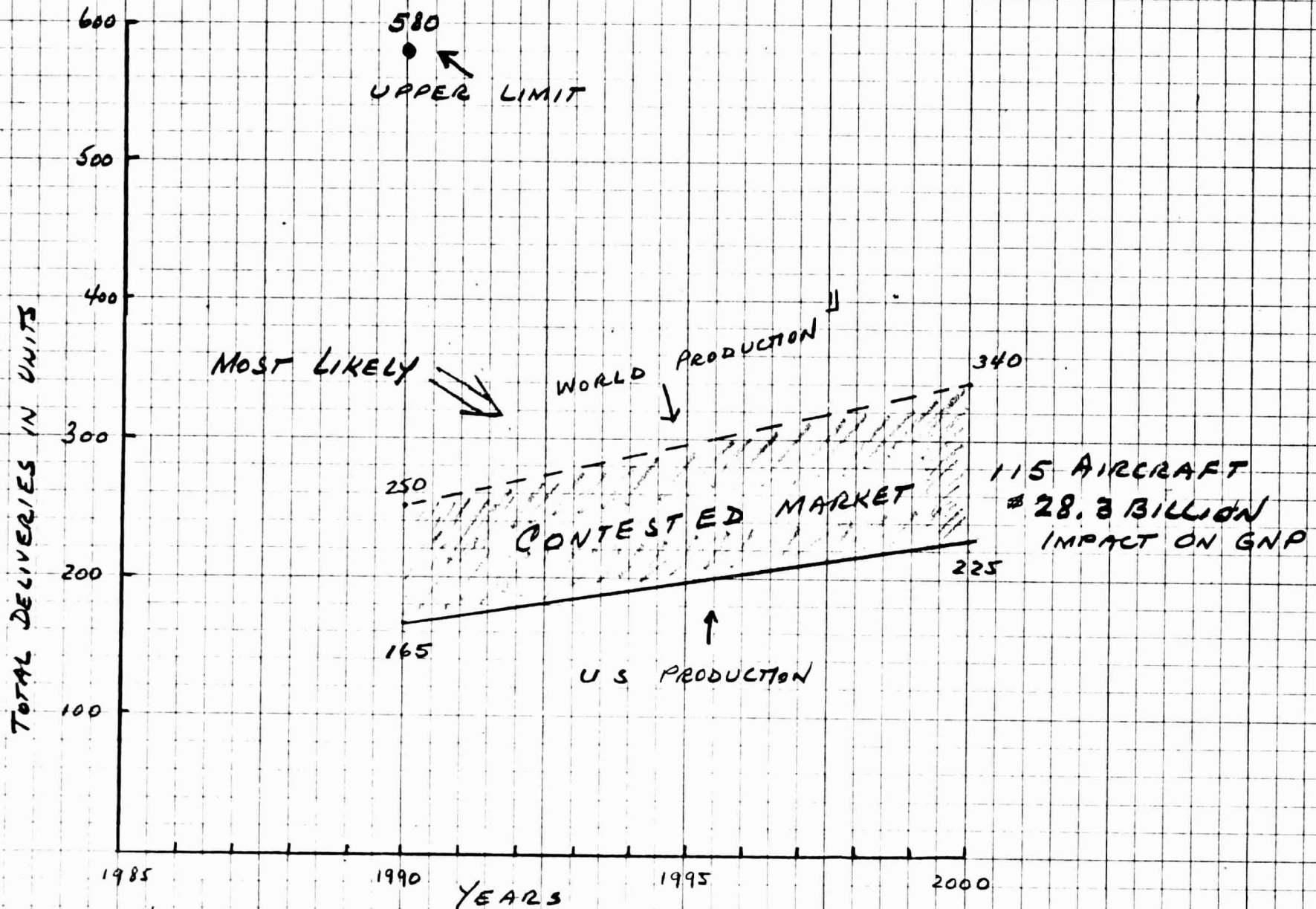
FORECAST OF WORLD SUPERSONIC FLEET SIZE
1976 - 2000
DOUGLAS FORECASTS



SOURCES: 1973 FORECAST - CIAP MONOGRAPH 2, SEPT 1975 p. 8-70
1975 FORECAST - THE PASSENGER AIR TRANSPORT MARKET, 1975-1990, JUNE 1975
(ADJUSTED TO REDUCE CONCORDE PRODUCTION FROM 18 TO 16 IN 1978)

FIGURE 3

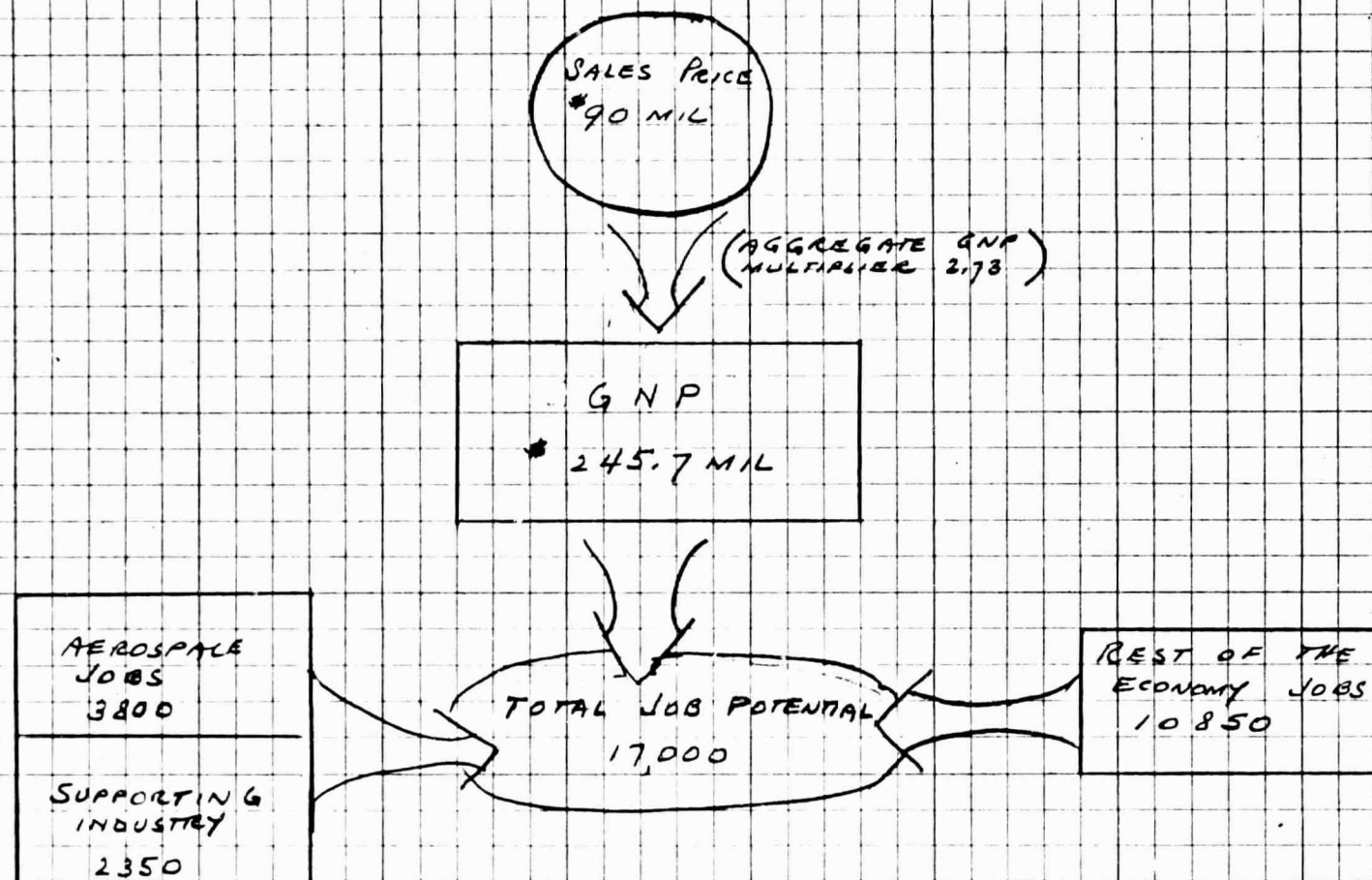
FORECAST OF WORLD SUPERSONIC FLEET SIZE
1990 - 2000
DELPHI FORECAST



1) WORLD PRODUCTION FORECASTED FOR 1990 ONLY. U.S. PRODUCTION FORECASTED FOR 1990 AND 2000. CHART ASSUMES THAT PERCENT OF MARKET SHARE WILL BE THE SAME IN 2000 AS IT IS IN 1990

FIGURE 4

ECONOMIC IMPACT OF ONE SUPERSONIC AIRCRAFT (1975 DOLLARS)



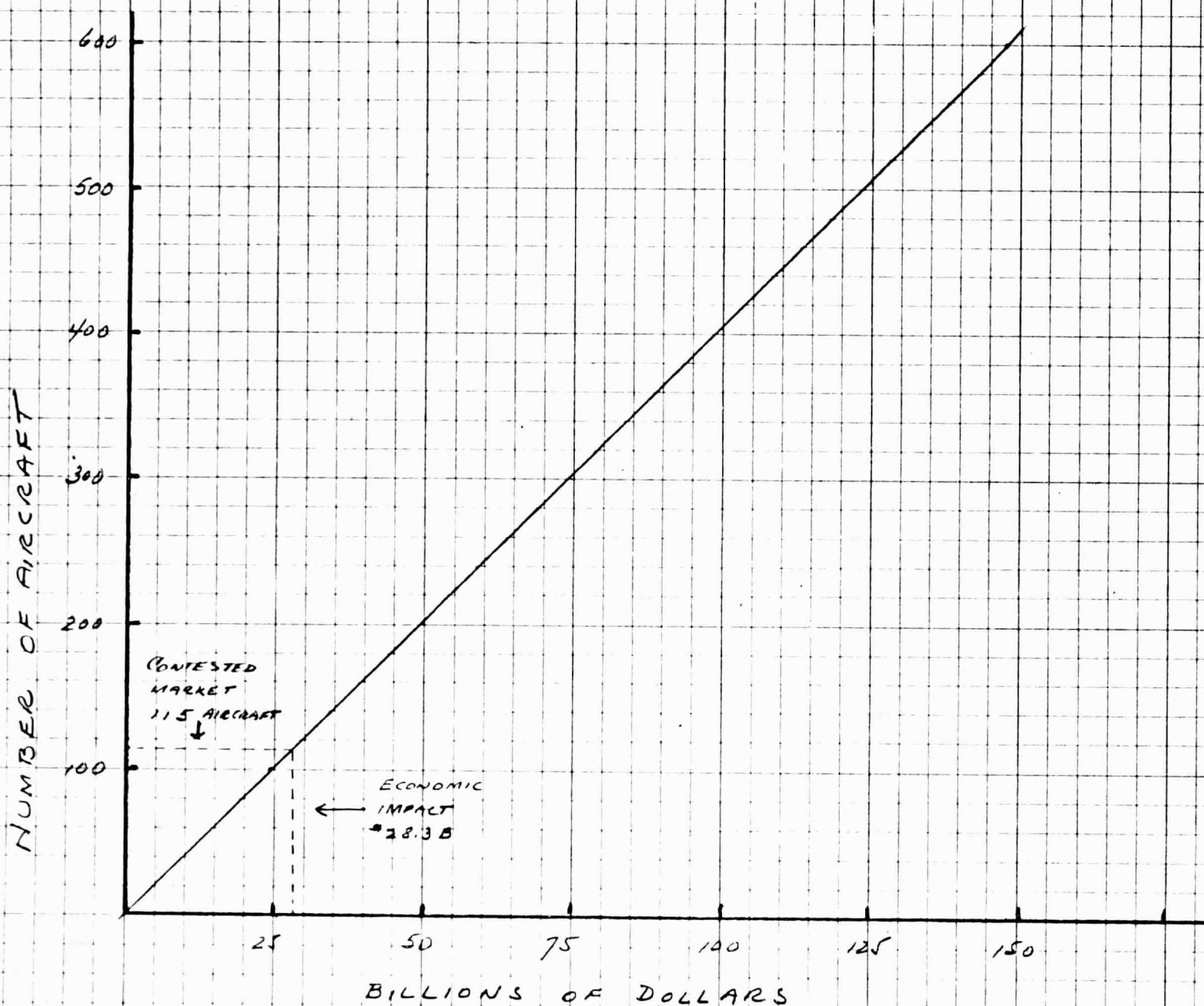
OTHER BENEFITS TO U.S. ECONOMY

- STATE/LOCAL TAX REVENUE \$28 MILLION
- FEDERAL TAX REVENUE \$49 MILLION
- FAVORABLE BALANCE OF TRADE

NOTE: ABOVE METHODOLOGY USES THE KEYNES AGGREGATE GNP MULTIPLIER CONCEPT TOGETHER WITH MANPOWER RELATIONSHIPS DEVELOPED IN A CASE STUDY OF - A MILITARY AIRCRAFT DEVELOPMENT PROGRAM, PREPARED BY ROCKWELL INTERNATIONAL, MARCH 14, 1975.

FIGURE 5

ECONOMIC IMPACT OF CONTESTED MARKET FOR SUPERSONIC AIRCRAFT



SUPERSONIC AIRCRAFT
FORECASTED ECONOMIC BENEFITS

Prepared by:

Operations Research, Inc.

July 15, 1976

FORECASTS OF SUPERSONIC TRANSPORT PROGRAM

Scenario I

New Technology Supersonic Transport (SST)

- Technology Development Phase 1981 - 82
- Concurrent Engine And Airframe
Development Phase 1987 - 88
- Start Production 1988 - 89
- Start Shipments 1989
- Total Shipments Of 309 By 2000
- No Competition
- 50 Percent For U. S. Airlines
And 50 Percent For Non-U.S. Airlines
- If U.S. Does Not Develop And Produce
The SST, U.S. Will Import To Meet
Requirements

Scenario II

Advanced Supersonic Transport (AST)

- U.S. Will Produce The Airframe. The Engine
Will Be A Foreign Made Advanced Olympus 593
- Start Shipments 1985
- Total Shipments Of 350 By 2000
- No Competition
- 50 Percent For U.S. Airlines And 50 Percent
FOR Non-U.S. Airlines

TABLE 1
U. S. ECONOMY - JOBS

- U. S. Unemployment Rate in December 1975 was Highest Among Large Industrial Countries:
 - U. S Unemployment Rate 8.5 Percent
 - U. S. Unemployed People 7.7 Million
 - Average Number Receiving Unemployment Compensation 5.2 Million
 - Unemployment Compensation Paid in 1975 . . . \$18.4 Billion
 - Additional New Jobs Needed Every Year Through 1980 1.5 Million
 - Economic Assumption By The President For 1981 Is An Unemployment Rate of 4.9 Percent
- Unemployment is an Economic "Minus"
 - Unemployed Married Person With One Child Living in Pennsylvania Who Earned \$200 Per Week When Working Can Receive \$5,900 In Unemployment Compensation.
- Restoring Job At \$11000 Per Year Will Result In An Economic "Plus" of \$7,900:

- Federal Income Tax	\$ 1,000
- State, Local And Other Taxes	970
- Eliminated Unemployment Compensation	<u>5,900</u>
- Economic Plus	\$ 7,870

TABLE 2

NEW TECHNOLOGY SUPERSONIC TRANSPORT PROGRAM (SST)
ECONOMIC BENEFITS TO THE NATIONAL ECONOMY
(1975 Constant Dollars)

<u>Actions</u>	<u>Year</u>
• Continued Technology Development Until	1981 - 82
• Concurrent Engine and Airframe Development	1987 - 88
• Start Production	1988 - 89
• Start Shipments	1989
• Total Shipments of 309 SSTs by	2000

BENEFITS

- Development Phase Will Add:
 - Over Man Years of Employment
 - Over Thousand Jobs at Peak of Development
 - Approx. Billion to the National Economy
 - Approx. Billion to Federal Taxes
 - Approx. Billion to State and Local Taxes
- Production Phase Will Add:
 - Over 1.8 Million Man Years of Employment
 - Over 165 Thousand Jobs at Peak of Production
 - Approx. \$62.6 Billion to the National Economy (GNP)
 - Approx. \$12.5 Billion to Federal Taxes
 - Approx. \$7.4 Billion to State and Local Taxes
 - Approx. \$16.0 Billion to U. S. Trade Balance

TABLE 3
FORECAST OF ADVANCED SUPERSONIC AIRCRAFT SHIPMENTS
1985 - 2000

Year	Advanced Supersonic ^{1/} Transport (AST)		New Technology ^{2/} SST	
	By Year	Cumulative	By Year	Cumulative
1985	2	2		
1986	8	10		
1987	16	26		
1988	15	41		
1989	20	61	20	20
1990	22	83	22	42
1991	26	109	26	68
1992	26	135	26	94
1993	26	161	26	120
1994	26	187	26	146
1995	27	214	27	173
1996	27	241	27	200
1997	27	268	27	227
1998	27	295	27	254
1999	27	322	27	281
2000	28	350	28	309

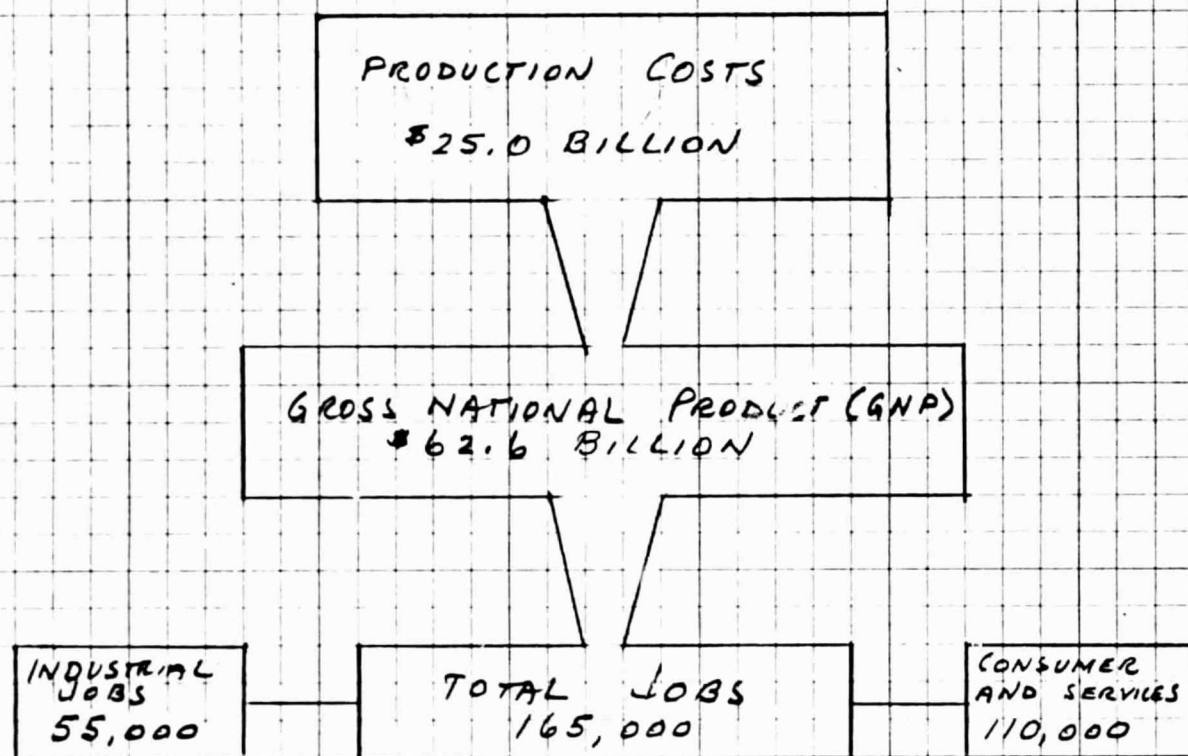
^{1/} 1985 - 1990 forecast published in, "The Passenger Air Transport Market, 1975 - 1990," June 1975, Douglas Aircraft Company. Forecast for 1991-2000 provided as a total number by Mr. Lucien Rochte, Supersonic Group, Douglas Aircraft Company, 9 July 1976. This is referred to by Douglas as the Advanced Supersonic Transport (AST). Annual delivery rates for 1991 - 2000 were assumed at levels indicated above.

^{2/} Boeing (Mr. John Granville) advised on 12 July 1976 that previous SST forecasts made by Boeing are no longer valid and should not be used. Mr. Lloyd Goodman, Boeing advised that no recent marketing studies were made by Boeing on the SST. Assumption is made in this report that deliveries will not start until 1989 and will be at the same delivery rate as the Douglas AST. This allows for continued technology development until 1981-82 and then start development on engine and air-frame concurrently.

SCENARIO I

NEW TECHNOLOGY SUPERSONIC TRANSPORT
PROGRAM

ECONOMIC IMPACT OF SCENARIO 1
NEW TECHNOLOGY SUPERSONIC TRANSPORT PROGRAM
1989 - 2000
(1975 CONSTANT DOLLARS)

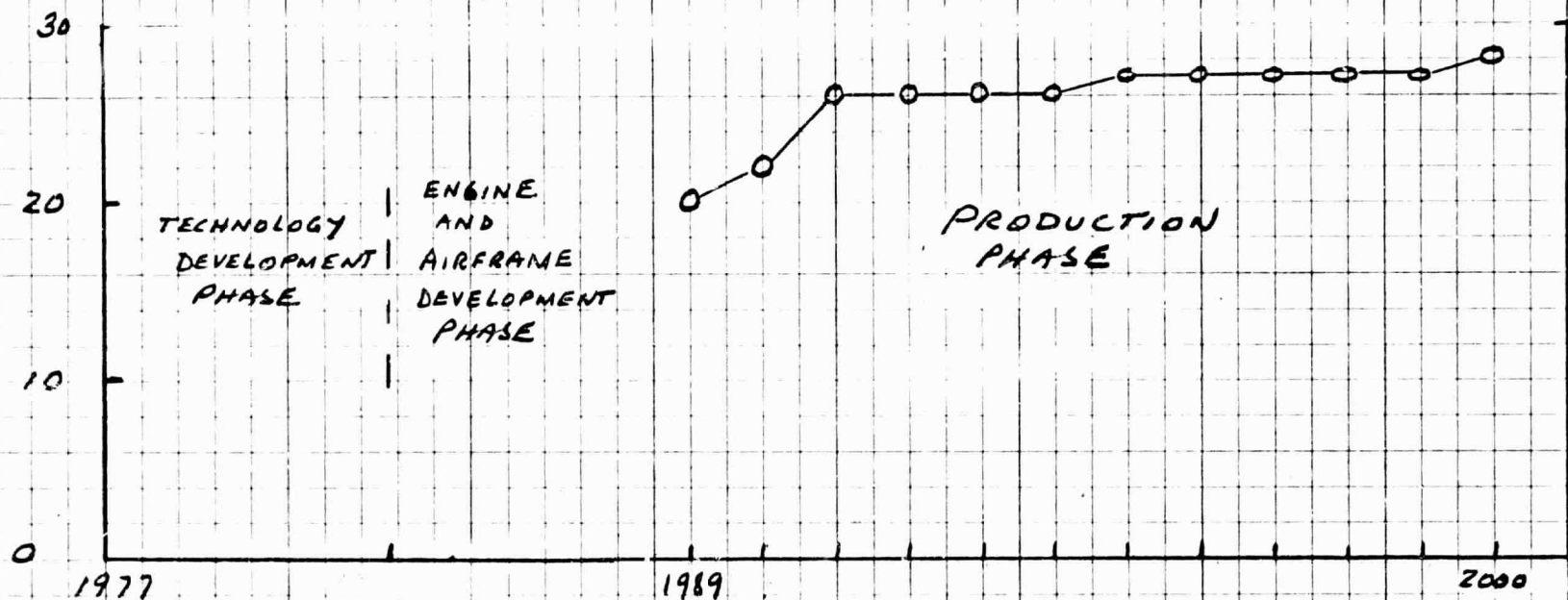


OTHER BENEFITS

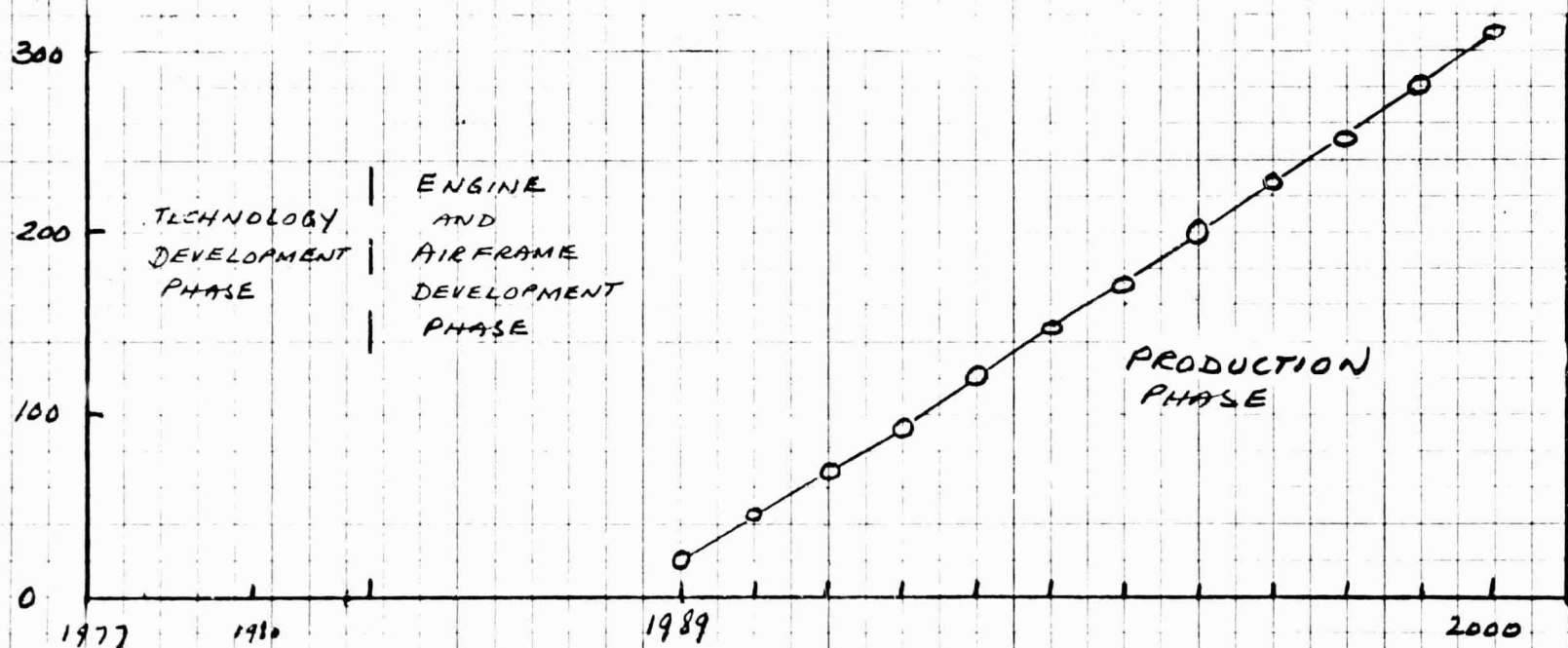
FAVORABLE BALANCE OF TRADE	* 16.0 BILLION
FEDERAL TAXES	* 12.5 BILLION
STATE AND LOCAL TAXES	* 7.4 BILLION

FORECAST NEW TECHNOLOGY SUPERSONIC TRANSPORT PROGRAM 1977 - 2000

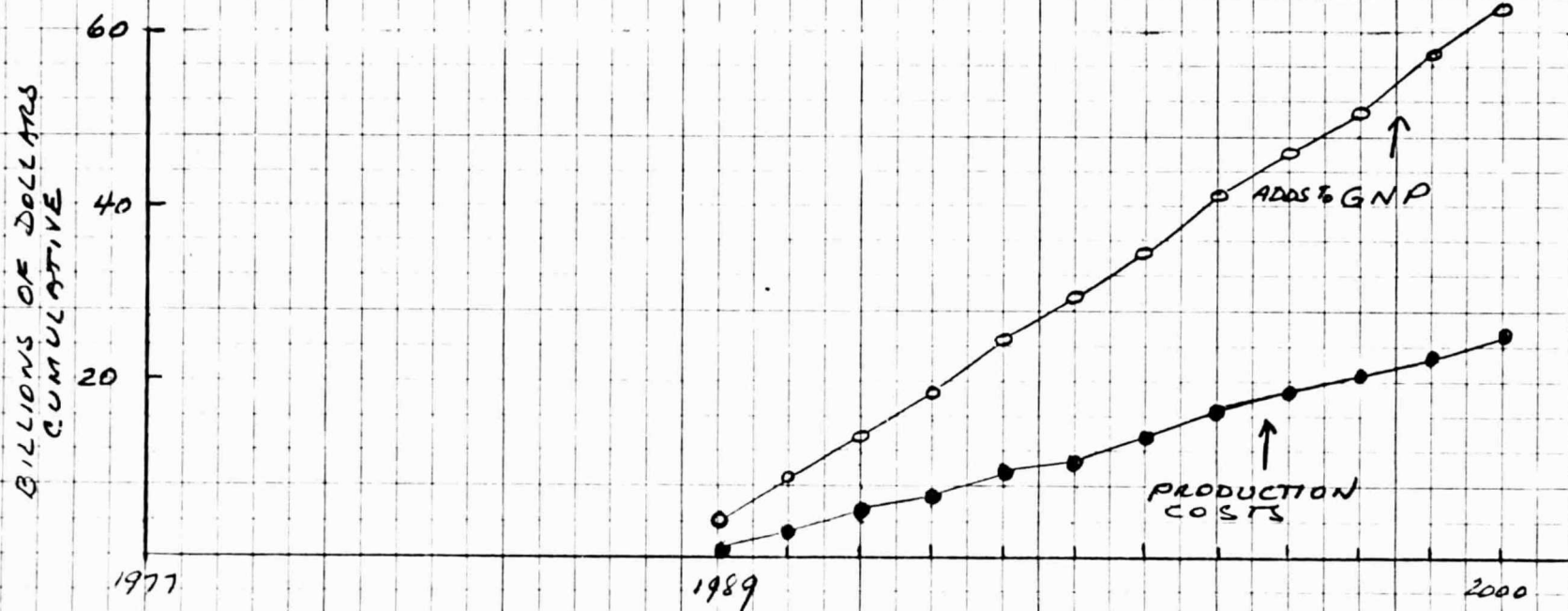
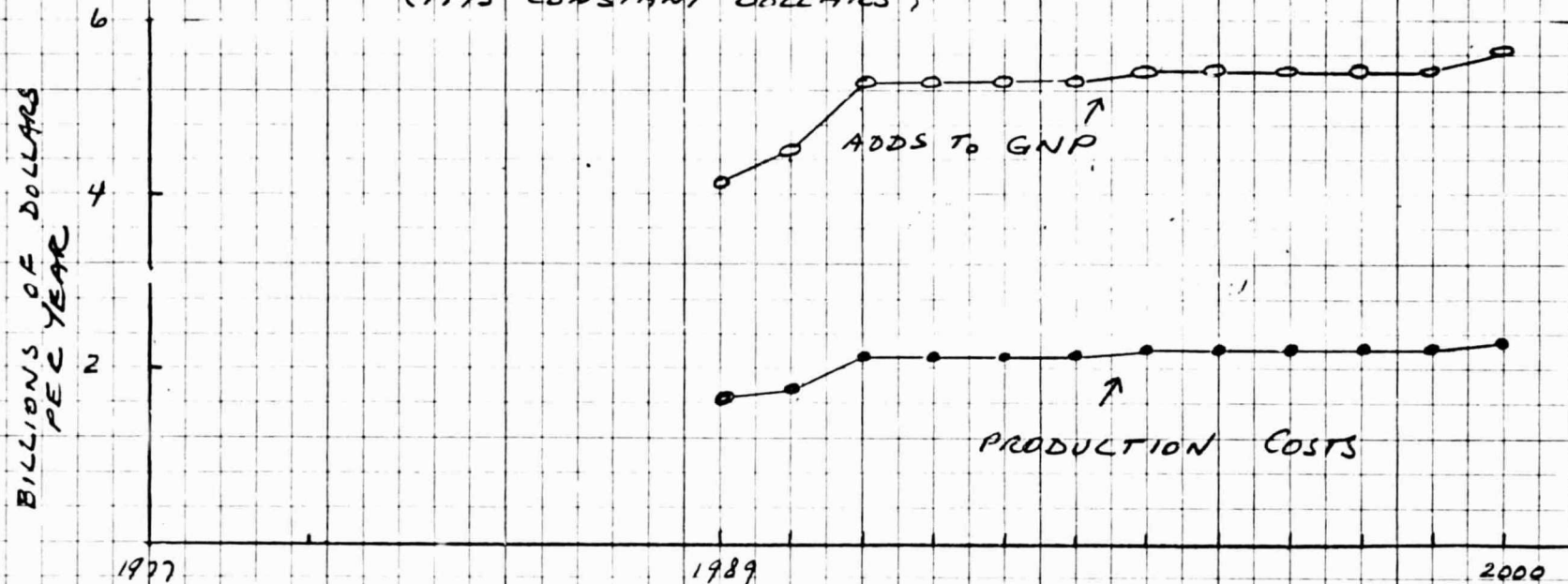
NUMBER OF AIRCRAFT
BY YEAR



CUMULATIVE NUMBER
OF AIRCRAFT

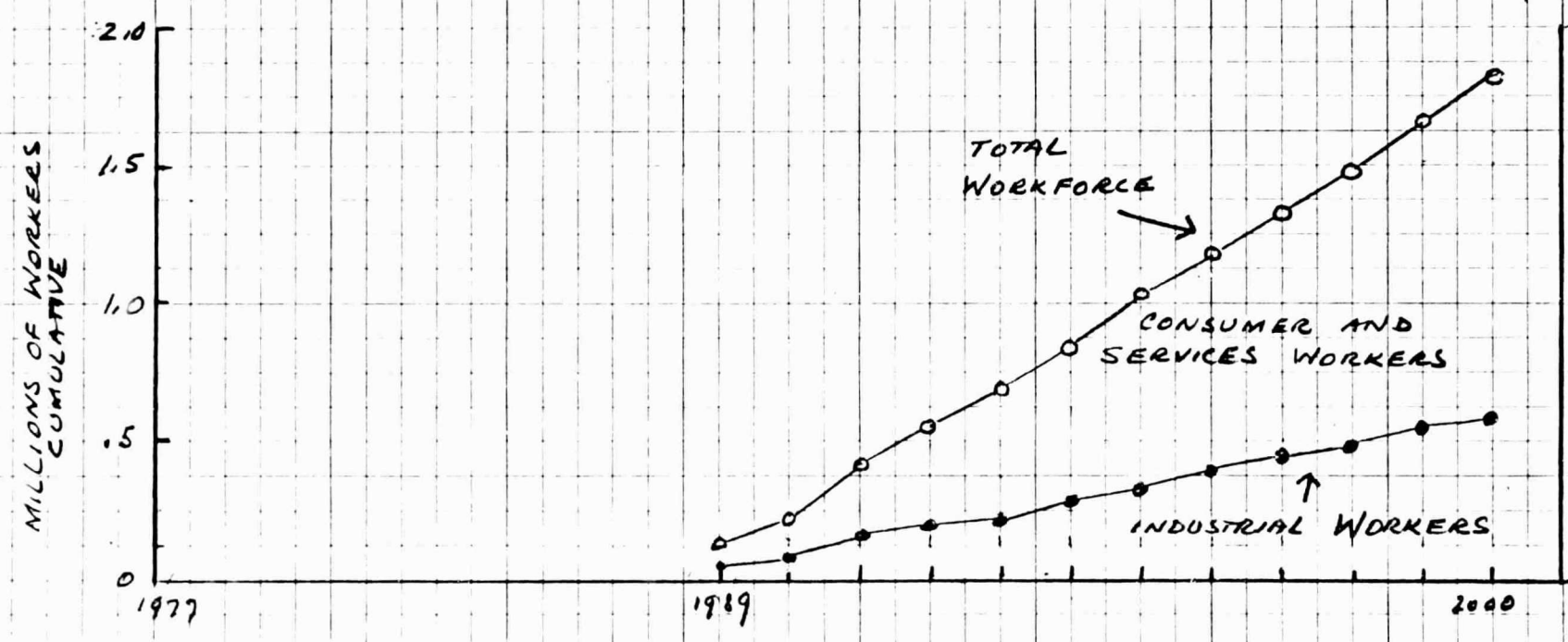
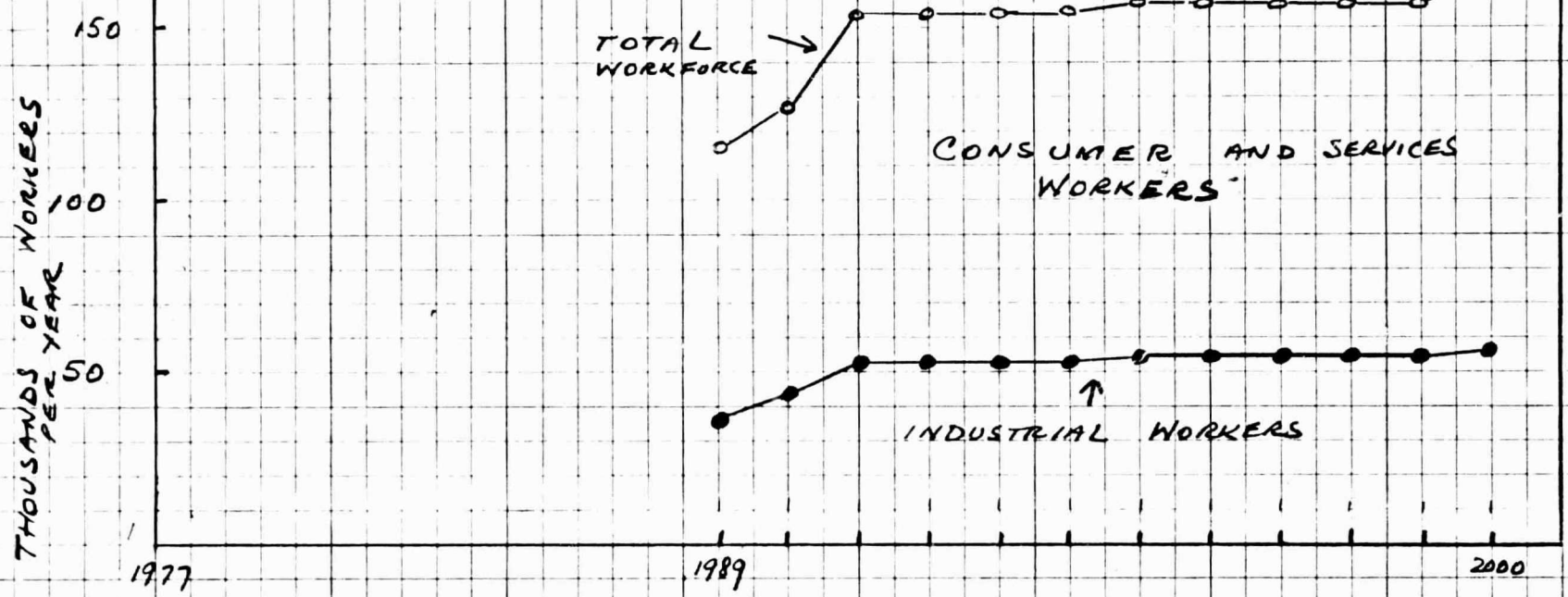


NEW TECHNOLOGY SUPERSONIC TRANSPORT PROGRAM
IMPACT ON GNP — 1977-2000
(1975 CONSTANT DOLLARS)



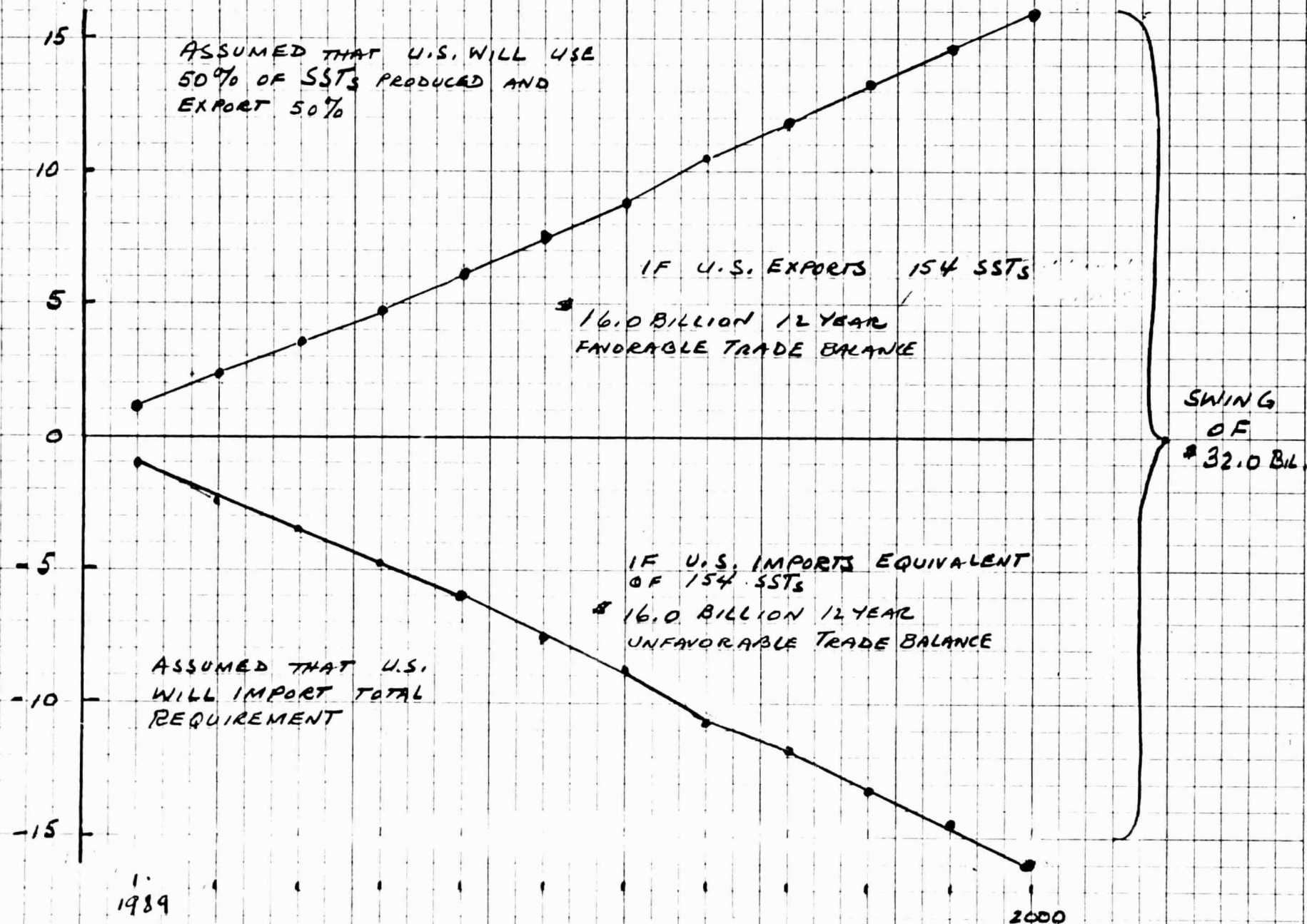
FORECAST

NEW TECHNOLOGY SUPERSONIC TRANSPORT FREIGHTER IMPACT ON MANPOWER 1977-2000



FORECAST

NEW TECHNOLOGY SUPERSONIC TRANSPORT PROGRAM IMPACT ON BALANCE OF TRADE — 1989-2000 (1975 CONSTANT DOLLARS)

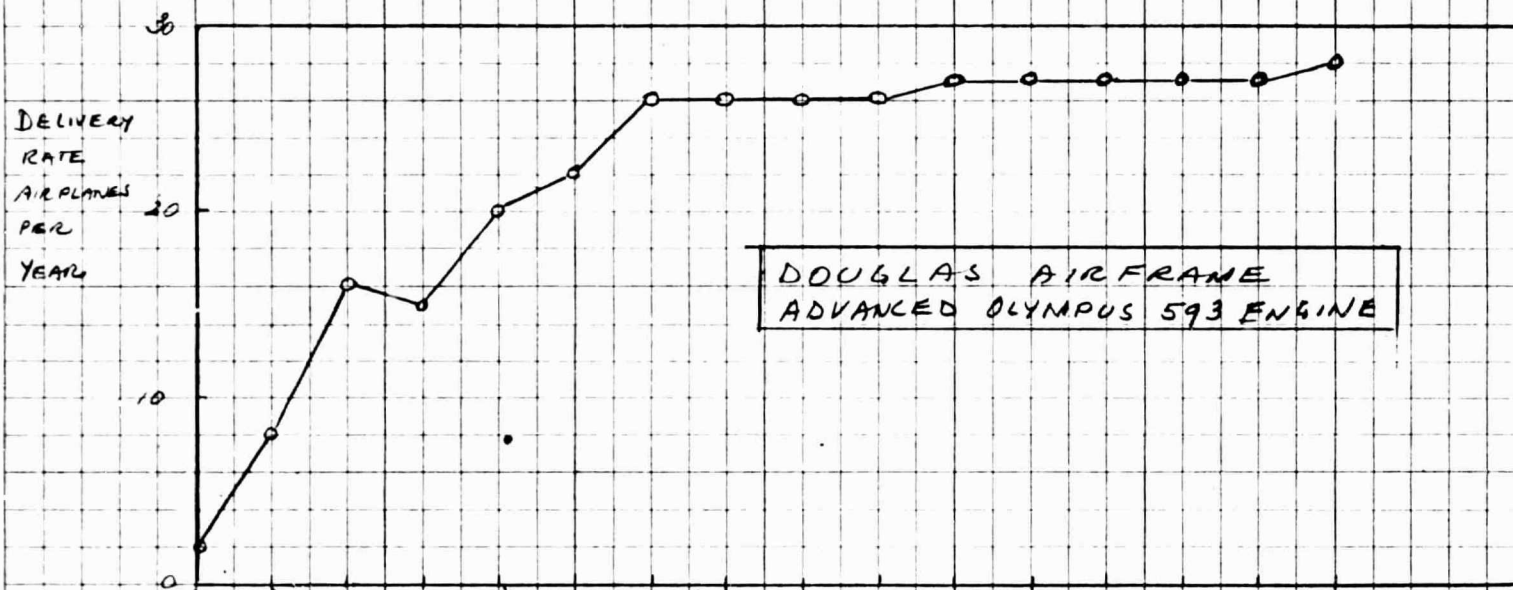


SCENARIO II

ADVANCED SUPERSONIC TRANSPORT (AST)
PROGRAM

ADVANCE

SUPERSONIC TRANSPORT (AST) 1985 - 2000

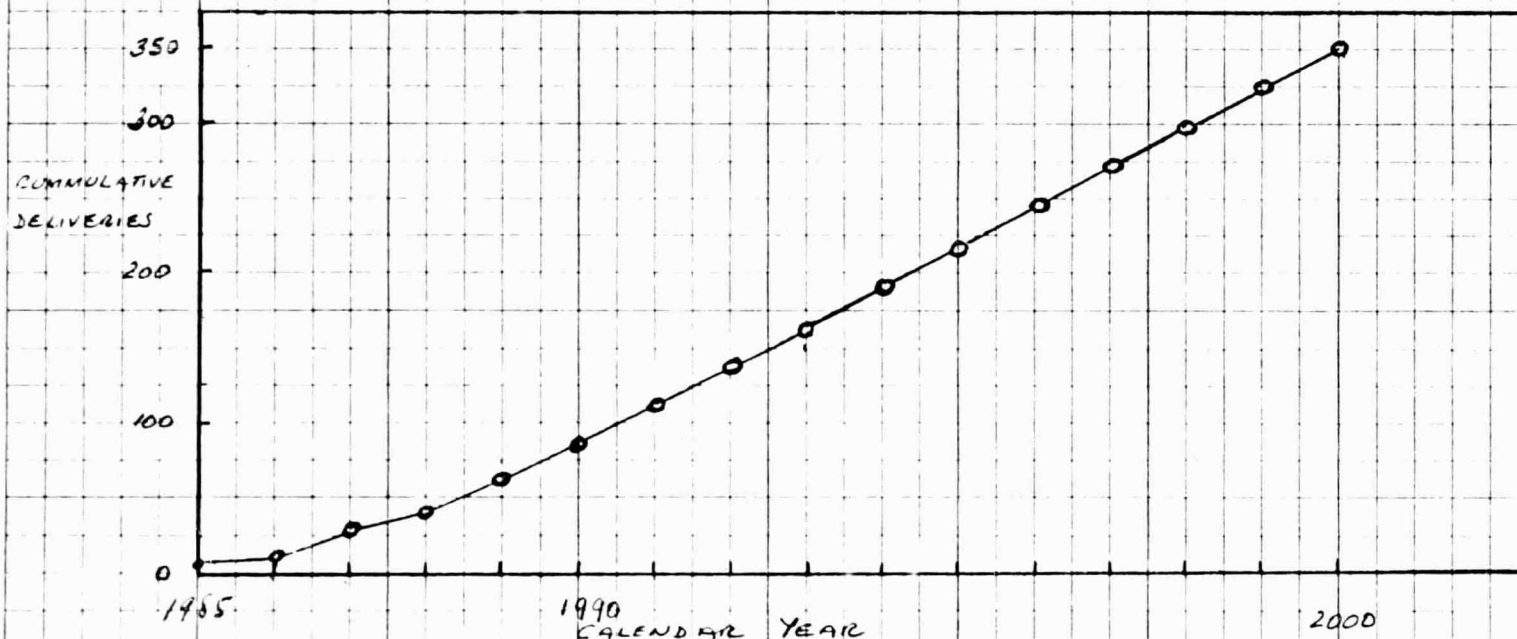


SOURCE:

1985-1990 - Statistics per
Air Transport market,
1975-1990, June 1975,
Douglas Aircraft Co.
Report C1-804-3672A.

1991-2000 - Telephone
information from
Mr. Lucien Rochte,
Supersonic Group,
Douglas Aircraft
Co., 9 July 1976.
(350-750)

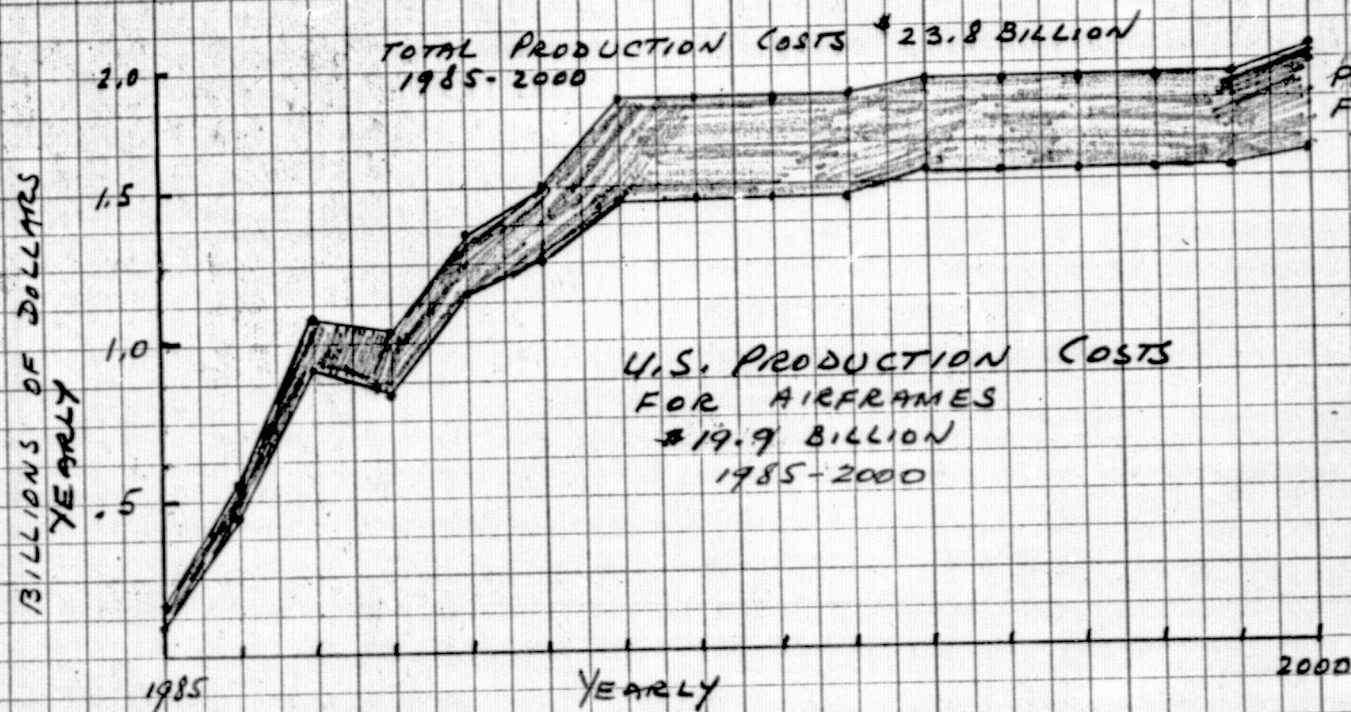
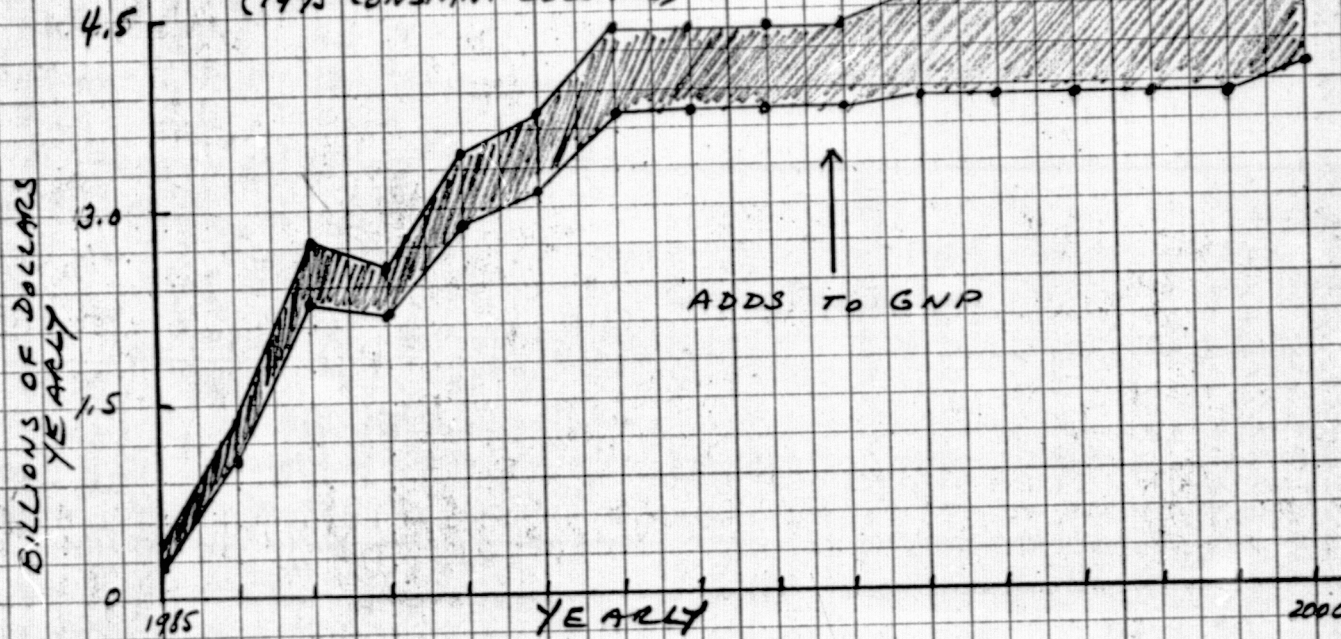
AW&ST JULY 5, 1976
US AIRFRAME
OLYMPUS 593 ENGINE



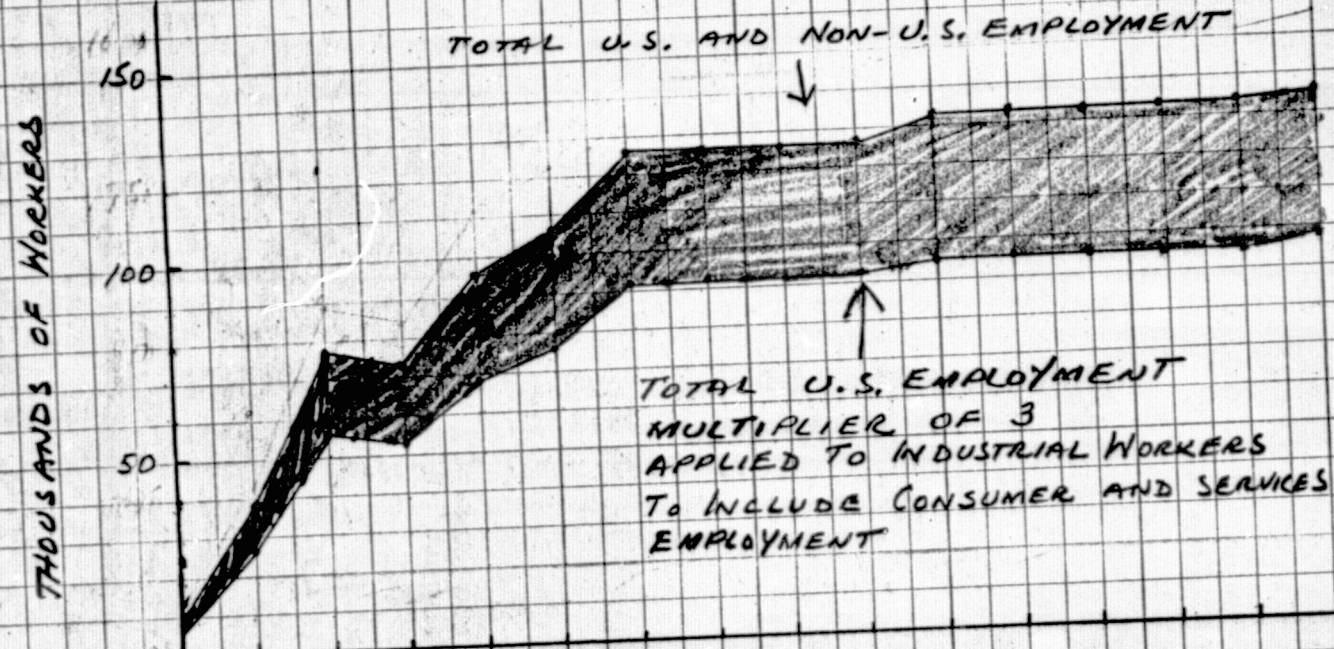
ADVANCED SUPERSONIC TRANSPORT (AST) DELIVERIES
(SUCCESSOR TO CONCORDE SUPERSONIC AIRLINER)

FORECAST

ADVANCED SUPERSONIC TRANSPORT (AST) PROGRAM
IMPACT ON GNP 1985-2000
(1975 CONSTANT DOLLARS)

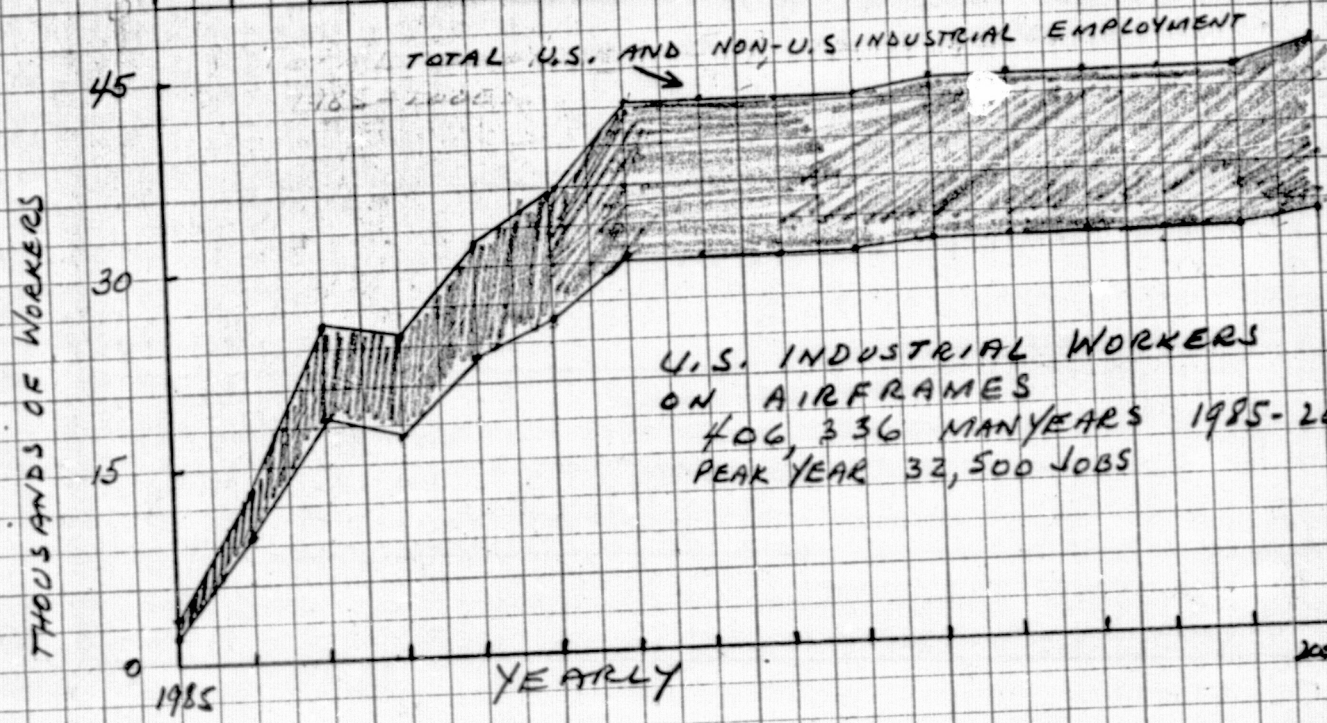


FORECAST ADVANCED SUPERSONIC TRANSPORT (AST) PROGRAM IMPACT ON MANPOWER 1985-2000



JOBS LOST TO U.S.
EMPLOYEES, 488,300
1985-2000
PEAK YEAR 39,000 JOBS

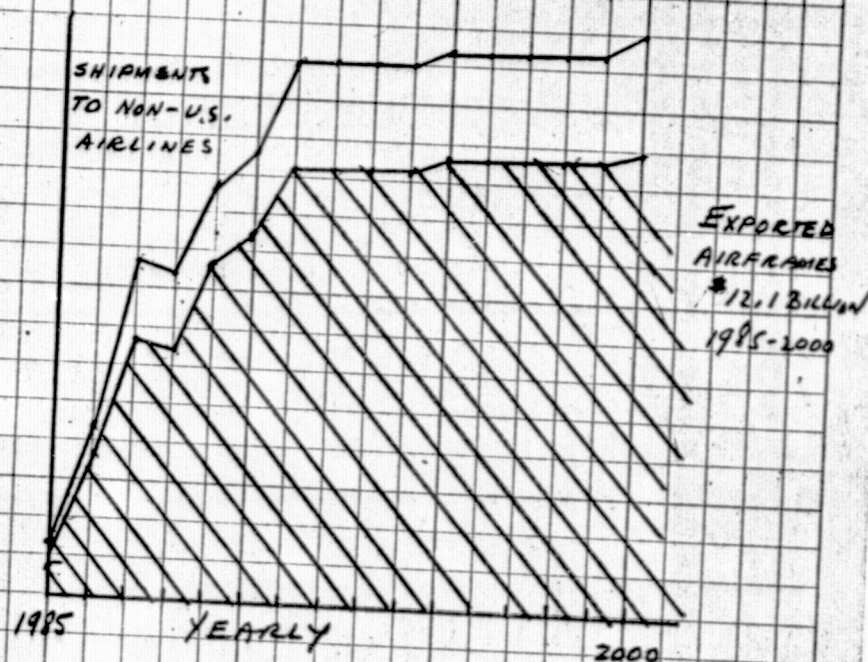
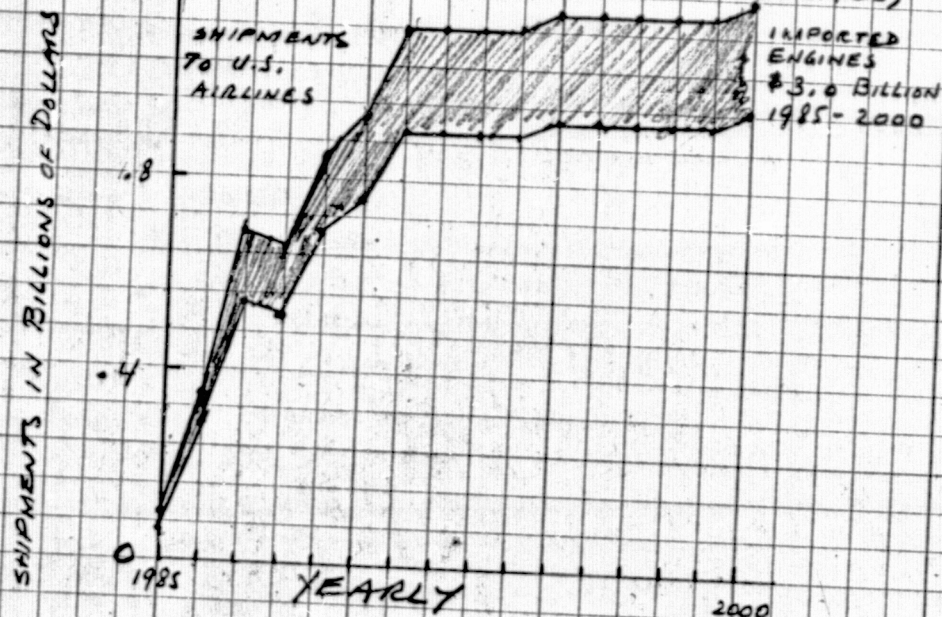
TOTAL MANYEARS
1,219,000
1978-2000
PEAK YEAR 97,500 JOBS



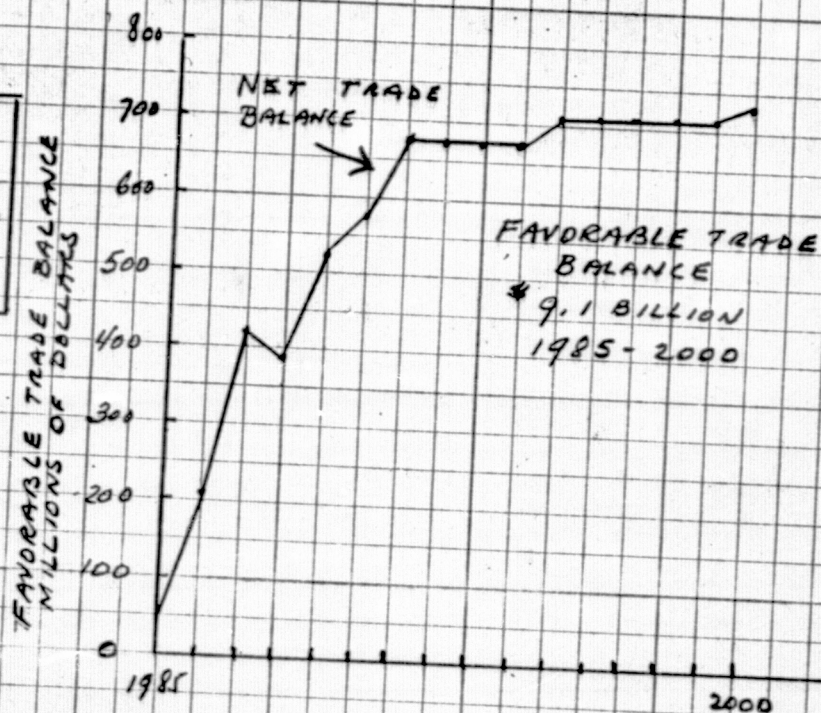
NON-U.S. INDUSTRIAL
WORKERS ON ENGINES
162,764 MANYEARS
1985-2000
PEAK YEAR 13,000 JOBS

U.S. INDUSTRIAL WORKERS
ON AIRFRAMES
406,336 MANYEARS 1985-2000
PEAK YEAR 32,500 JOBS

FACE-4ST ADVANCED SUPERSONIC TRANSPORT (AST) PROGRAM IMPACT ON BALANCE OF TRADE (1975 CONSTANT DOLLARS) 1985-2000



ASSUMPTION:
U.S. AIRLINES WILL
ORDER 50% OF THE ASTs,
NON-U.S. AIRLINES WILL
ALSO ORDER 50%.



\$6.0 BILLION IN
TRADE BALANCE
LOST TO U.S.
BECAUSE OF FOREIGN
MANUFACTURE OF
ENGINES

TABLE 1

WORKSHEET

FORECAST OF NEW TECHNOLOGY SST SHIPMENTS
IMPACT ON GNP1989 - 2000
(1975 CONSTANT DOLLARS IN MILLIONS)

YEAR	SHIPMENTS ^{1/}		PRODUCTION ^{2/}	CUM	IMPACT ^{3/}		CUM
	NUMBER	AMOUNT	COSTS		ON	GNP	
1989	20	\$1,800	\$1,620		\$4,050		
1990	22	1,980	1,782	3402	4,455	8505	
1991	26	2,340	2,106	5508	5,265	13770	
1992	26	2,340	2,106	7614	5,265	19035	
1993	26	2,340	2,106	9720	5,265	24300	
1994	26	2,340	2,106	11826	5,265	29565	
1995	27	2,430	2,187	14013	5,467	35032	
1996	27	2,430	2,187	16200	5,467	40999	
1997	27	2,430	2,187	18387	5,468	45967	
1998	27	2,430	2,187	20574	5,468	51435	
1999	27	2,430	2,187	22761	5,468	56903	
2000	28	2,520	2,268	25029	5,670	62573	
TOTAL	309	\$27,810	\$25,029		\$62,573		

1/ Computed at assumed sales price of \$90 million each.

2/ Computed at assumed production cost of \$81 million each (allows for an 11.0 percent profit margin).

3/ Aggregate GNP multiplier of 2.5 ^(applied to production costs) used in this study.

Bosung (The SST Program and Related National Benefits, February 17, 1969) used a relatively conservative GNP multiplier of 2 in evaluating the benefits of the SST.

Rockwell International in "Understanding the Impact of Aerospace Programs on the National Economy," March 14, 1975 used an aggregate GNP multiplier of 2.73 in projections through 1985.

TABLE 2
ESTIMATED MANPOWER REQUIREMENTS
RELATED TO BOEING SST PRODUCTION
1989 - 2000

WORKSHEET

YEAR	SST'S PRODUCED	TOTAL INDUSTRIAL EMPLOYMENT	11 CUM	U.S. CONSUMER AND SERVICES EMPLOYMENT	TOTAL EMPLOYMENT	21 CUM
1989	20	39,220		78,440	117,660	
1990	22	43,142	82362	86,284	129,426	247086
1991	26	50,986	133348	101,972	152,958	400044
1992	26	50,986	184334	101,972	152,958	553002
1993	26	50,986	235320	101,972	152,958	705960
1994	26	50,986	286305	101,972	152,958	858918
1995	27	52,947	339253	105,894	158,841	1017759
1996	27	52,947	392200	105,894	158,841	1176600
1997	27	52,947	445147	105,894	158,841	1335441
1998	27	52,947	498094	105,894	158,841	1494282
1999	27	52,947	551041	105,894	158,841	1653123
2000	28	54,908	605949	109,816	164,724	1817847
TOTAL	309	605,949		1,211,898	1,817,847	

11 The approximate number of industrial employees related to SST production, an average of 1961, was derived from Table 4-IV and 5-I, Boeing, "The SST Program and Related National Benefits, February 17, 1969.

21 A multiplier of 3 has been applied to industrial workers associated with the SST in all studies reviewed and in Congressional testimony to include the secondary ~~employment~~ effects of consumer and services employment.

TABLE 3
FORECAST OF NEW TECHNOLOGY SST SHIPMENTS
IMPACT ON BALANCE OF TRADE
1989-2000
(1975 CONSTANT DOLLARS IN MILLIONS)

WORKSHEET

(ASSUME 50/50 SPLIT)

(ASSUME 46/54 SPLIT)

YEAR	TOTAL	U.S.	FOREIGN			U.S.	FOREIGN		
			SST	SPARES	TOTAL EXPORTS		SST	SPARES	TOTAL EXPORTS
1989	1,800	900	900	135.0	1,035.0	878.0	977.0	145.8	1,117.8
1990	1,980	990	990	148.5	1,138.5	910.8	1,069.2	160.4	1,229.6
1991	2,340	1,170	1,170	175.5	1,345.5	1,076.4	1,263.6	189.5	1,453.1
1992	2,340	1,170	1,170	175.5	1,345.5	1,076.4	1,263.6	189.5	1,453.1
1993	2,340	1,170	1,170	175.5	1,345.5	1,076.4	1,263.6	189.5	1,453.1
1994	2,340	1,170	1,170	175.5	1,345.5	1,076.4	1,263.6	189.5	1,453.1
1995	2,430	1,215	1,215	182.2	1,397.2	1,117.8	1,312.2	196.8	1,509.0
1996	2,430	1,215	1,215	182.2	1,397.2	1,117.8	1,312.2	196.8	1,509.0
1997	2,430	1,215	1,215	182.3	1,397.3	1,117.8	1,312.2	196.8	1,509.0
1998	2,430	1,215	1,215	182.3	1,397.3	1,117.8	1,312.2	196.8	1,509.0
1999	2,430	1,215	1,215	182.3	1,397.3	1,117.8	1,312.2	196.8	1,509.0
2000	2,520	1,260	1,260	189.0	1,449.0	1,159.2	1,360.8	204.1	1,564.9
TOTAL	27,810	13,905	13,905	2,085.8	15,990.8	12,792.6	15,017.4	2,252.6	17,270.0

Totals may not add due to rounding.

ASSUMPTIONS:

- a. That the New Technology SST has no competition
- b. That 50 percent of the shipments will be to U.S. airlines and 50 percent to foreign airlines.

- OR -

That 46 percent of the shipments will be to U.S. airlines and 54 percent to foreign airlines. This number has been used in many studies and publications related to the SST.

- c. That engine and airframe spares are approximately 15 percent of the cost of the aircraft in accordance with methodology used by Boeing in their 1969 study on the SST. This does not include follow on spares over time.

FORECAST OF ADVANCED SUPERSONIC TRANSPORT (AST) SHIPMENTS
IMPACT ON GNP
1985-2000
(1975 CONSTANT DOLLARS IN MILLIONS)

YEAR	SHIPMENTS ^{1/}		SHARE OF SALES		PRODUCTION COSTS ^{2/}			IMPACT ^{3/}	
	NUMBER	AMOUNT	NON-U.S.	U.S.	TOTAL	NON-U.S.	U.S.	ON GNP	LOSS TO U.S. GNP
1985	2	\$ 150	\$ 24.3	\$ 125.7	\$ 136	\$ 22.0	\$ 114.0	\$ 285.0	\$ 55.0
1986	8	600	97.2	503.8	544	88.1	455.9	1,139.8	220.3
1987	16	1,200	194.4	1,005.6	1,088	176.3	911.7	2,279.3	440.8
1988	15	1,125	182.3	942.7	1,020	165.2	854.8	2,137.0	413.0
1989	20	1,500	243.0	1,257.0	1,360	220.3	1,139.7	2,849.3	550.8
1990	22	1,650	267.3	1,382.7	1,496	242.4	1,253.6	3,134.0	606.0
1991	26	1,950	315.9	1,634.1	1,768	286.4	1,481.6	3,704.0	716.0
1992	26	1,950	315.9	1,634.1	1,768	286.4	1,481.6	3,704.0	716.0
1993	26	1,950	315.9	1,634.1	1,768	286.4	1,481.6	3,704.0	716.0
1994	26	1,950	315.9	1,634.1	1,768	286.4	1,481.6	3,704.0	716.0
1995	27	2,025	328.1	1,696.9	1,836	297.4	1,538.6	3,846.5	743.5
1996	27	2,025	328.1	1,696.9	1,836	297.4	1,538.6	3,846.5	743.5
1997	27	2,025	328.0	1,697.0	1,836	297.4	1,538.6	3,846.5	743.5
1998	27	2,025	328.0	1,697.0	1,836	297.4	1,538.6	3,846.5	743.5
1999	27	2,025	328.0	1,697.0	1,836	297.4	1,538.6	3,846.5	743.5
2000	28	2,100	340.2	1,759.8	1,904	308.4	1,595.6	3,989.0	771.0

TOTAL * 350 * 26,250 * 4,252.5 * 21,997.5 * 23,800 * 3,855.6 * 19,944.4 * 49,861.0 * 9,639.0

* Totals may not add due to rounding.

1/ Computed at assumed sales price of \$75 million each based on seat capacity relationship to the Boeing SST (298 vs 250)

2/ Computed at production cost of \$68 million under same principle as sales price - allows for a 10.3 percent profit margin. The non-U.S. amount was computed on the relationship that the engine cost is to the airplane cost using the Boeing amounts in, "The SST in Commercial Operation", May 1969, p. D-5 (16.2 percent of the cost).

3/ An aggregate GNP multiplier of 2.5 was used to determine the impact on the GNP and the loss to the U.S. economy due to overseas manufacture of the engine.

TABLE 3
ESTIMATED MANPOWER REQUIREMENTS
RELATED TO DOUGLAS AST PRODUCTION
U.S. VERSUS NON-U.S.
1985-2000

YEAR	ASTs PRODUCED	INDUSTRIAL EMPLOYMENT			U.S. CONSUMER AND SERVICES EMPLOYMENT	TOTAL U.S. EMPLOYMENT	TOTAL LOSS OF U.S. EMPLOYMENT
		TOTAL ^{1/}	NON-U.S. ^{2/}	U.S.			
1985	2	3,252	930	2,322	4,644	6,966	2,790
1986	8	13,008	3,720	9,288	18,576	27,864	11,160
1987	16	26,016	7,441	18,575	37,150	55,725	22,323
1988	15	24,390	6,976	17,414	34,818	52,242	20,928
1989	20	32,520	9,301	23,219	46,438	69,657	27,903
1990	22	35,772	10,231	25,541	51,082	76,623	30,693
1991	26	42,276	12,091	30,185	60,370	90,555	36,273
1992	26	42,276	12,091	30,185	60,370	90,555	36,273
1993	26	42,276	12,091	30,185	60,370	90,555	36,273
1994	26	42,276	12,091	30,185	60,370	90,555	36,273
1995	27	43,902	12,556	31,346	62,692	94,038	37,668
1996	27	43,902	12,556	31,346	62,692	94,038	37,668
1997	27	43,902	12,556	31,346	62,692	94,038	37,668
1998	27	43,902	12,556	31,346	62,692	94,038	37,668
1999	27	43,902	12,556	31,346	62,692	94,038	37,668
2000	28	45,528	13,021	32,507	65,014	97,521	39,063
TOTAL	350	569,100	162,764	406,336	812,672	1,219,008	488,292

^{1/} Industrial employment assumed to be approximately 83 percent of the number related to production of the Boeing new technology SST based on size of aircraft (298 seats on Boeing SST versus 250 seats on Douglas AST)

^{2/} Non-U.S. industrial employment assumed to be approximately 28.6 percent of total industrial employment since the AST contemplates the use of an advance version of the Olympus 593 engines now powering the Concorde. The 28.6 percent is the same relationship between Boeing employees and General Electric employees shown in the Boeing Study, "The SST Program and Related National Benefits", February 17, 1969.

^{3/} A multiplier of 3 has been applied to industrial workers associated with the SST. ~~in all studies and Congressional testimony to indicate the secondary employment effects of commercial aircraft manufacturing.~~

^{4/} Applying the multiplier of 3 to the non-U.S. industrial employment shows the loss of U.S. employees due to overseas manufacture of the engine.

FORECAST OF ADVANCED SUPERSONIC TRANSPORT (AST) SHIPMENTS
IMPACT ON BALANCE OF TRADE
1985 - 2000
(1975 CONSTANT DOLLARS IN MILLIONS)

YEAR	TOTAL	U.S. PRODUCED			NON-U.S. PRODUCED			ADJUSTED TOTAL
		AIRFRAME	SPARE	TOTAL	ENGINE	SPARE	TOTAL	
1985	150	125.7	12.6	138.3	24.3	9.7	34.0	172.3
1986	600	502.8	50.3	553.1	97.2	38.9	136.1	689.2
1987	1,200	1,005.6	100.6	1,106.2	194.4	77.5	271.9	1,378.1
1988	1,125	942.7	94.3	1,037.0	182.3	72.9	255.2	1,292.2
1989	1,500	1,257.0	125.7	1,382.7	243.0	97.2	340.2	1,722.9
1990	1,650	1,382.7	138.3	1,521.0	267.3	106.9	374.2	1,895.2
1991	1,950	1,634.1	163.4	1,797.5	315.9	126.4	442.3	2,239.8
1992	1,950	1,634.1	163.4	1,797.5	315.9	126.4	442.3	2,239.8
1993	1,950	1,634.1	163.4	1,797.5	315.9	126.4	442.3	2,239.8
1994	1,950	1,634.1	163.4	1,797.5	315.9	126.4	442.3	2,239.8
1995	2,025	1,696.9	169.7	1,866.6	378.1	131.2	459.3	2,325.9
1996	2,025	1,696.9	169.7	1,866.6	378.1	131.2	459.3	2,325.9
1997	2,025	1,697.0	169.7	1,866.7	378.0	131.2	459.2	2,325.9
1998	2,025	1,697.0	169.7	1,866.7	378.0	131.2	459.2	2,325.9
1999	2,025	1,697.0	169.7	1,866.7	378.0	131.2	459.2	2,325.9
2000	2,100	1,759.8	176.0	1,935.8	340.2	136.1	476.3	2,412.1
TOTAL	26,250	21,997.5	2,199.8	24,197.3	4,252.5	1,701.0	5,953.5	30,150.8

Totals may not add due to rounding.

ASSUMPTIONS:

- That the AST has no competition
- That 50 percent of the shipments will be to U.S. airlines and 50 percent to foreign airlines.
- That airframe spares are 10 percent of the cost of the airframe and engine spares are 40 percent of the cost of the 4 engines on the airplane in accordance with the methodology used by Boeing in their 1969 study on the SST. See next chart for additional computations.

FO. CAST OF ADVANCED SUPERSONIC TRANSPORT (AST) SHIPMENTS
IMPACT ON BALANCE OF TRADE
1985-2000
(1975 CONSTANT DOLLARS IN MILLIONS)
(ASSUME 50/50 SPLIT)

YEAR	TOTAL SHIPMENTS	U.S. SHIPMENT			FOREIGN SHIPMENT			TRADE BALANCE	
		TOTAL	DOMESTIC	IMPORT	TOTAL	DOMESTIC	EXPORT	GROSS	NET
1985	172.3	86.2	69.2	17.0	86.2	17.0	69.2	52.2	53.0
1986	689.2	344.6	276.6	68.0	344.6	68.0	276.6	208.6	212.0
1987	1,378.1	689.0	553.0	136.0	689.0	136.0	553.0	417.0	423.8
1988	1,292.2	646.1	518.5	127.6	646.1	127.6	518.5	390.9	397.3
1989	1,722.9	861.5	691.4	170.1	861.5	170.1	691.4	521.3	529.8
1990	1,895.2	947.6	760.5	187.1	947.6	187.1	760.5	573.4	582.8
1991	2,239.8	1,119.9	898.8	221.1	1,119.9	221.1	898.8	677.7	688.8
1992	2,239.8	1,119.9	898.8	221.1	1,119.9	221.1	898.8	677.7	688.8
1993	2,239.8	1,119.9	898.8	221.1	1,119.9	221.1	898.8	677.7	688.8
1994	2,239.8	1,119.9	898.8	221.1	1,119.9	221.1	898.8	677.7	688.8
1995	2,325.9	1,163.0	933.3	229.7	1,163.0	229.7	933.3	703.6	715.1
1996	2,325.9	1,163.0	933.3	229.7	1,163.0	229.7	933.3	703.6	715.1
1997	2,325.9	1,163.0	933.3	229.7	1,163.0	229.7	933.3	703.6	715.1
1998	2,325.9	1,163.0	933.3	229.7	1,163.0	229.7	933.3	703.6	715.1
1999	2,325.9	1,163.0	933.3	229.7	1,163.0	229.7	933.3	703.6	715.1
2000	2,412.1	1,206.0	967.9	238.1	1,206.0	238.1	967.9	729.8	741.7
TOTAL	30,150.8	15,075.4	12,098.7	2,976.7	15,075.4	2,976.7	12,098.7	9,122.0	9,270.3

Note - On shipments to U.S. airlines, the engines and engine spares are considered as imports whereas the airframe and airframe spares are considered as exports. The "gross trade balance" is the difference between the exports and the imports. The "net trade balance" reduces the imports by 5 percent since it is assumed that Douglas will get a portion of the savings on the engines.

NEW TECHNOLOGY SUPERSONIC TRANSPORT
FORECASTED ECONOMIC BENEFITS

Prepared by:
Operations Research, Inc.
July 22, 1976

INTRODUCTION AND SUMMARY

INTRODUCTION

This report covers the estimated costs and related benefits associated with the development of the new technology SST. The development costs involved range from \$5 - \$7 billion during the period 1978 to 1988 while the associated benefits cover the same development period together with the benefits derived from production during the period 1989 to 2000. These latter benefits are included in the ORI report delivered to NASA on July 15, 1976. All costs and benefits are stated in 1975 constant dollars. Additionally the benefits derived from Federal tax revenues during the production phase are also stated at their discounted present value for valid comparisons with the R&D investments. This conversion was not necessary during the development phase since the tax revenue is generally received during the same year the investment is made.

SUMMARY

Table 1 shows two selected problems that are of National concern -

Unemployment and U.S. Trade Balance. Unemployment is addressed in the Economic Report of the President, January 1976 while a NASA objective as stated in the FY 1977 President's Budget is to, "continue to advance the Nation's aeronautical technology to ... enable private industry to maintain a strong U.S. competitive position in the international Marketplace." The new technology SST program will have a favorable impact on both problems.

The planned actions, developments and related benefits (employment, GNP, Federal taxes, U.S. trade balance) are summarized in Table 2. The Table shows that if the government were to provide total funding of the R&D phase (\$7.0 billion) the Federal tax revenues at discounted present value would exceed the R&D costs by \$1.5 billion. The return on investment to the government would be increased by the amount of participation by industry during the R&D phase.

Table 3 shows a comparison of government spending under three alternatives using the large scale macroeconomic model of the Chase Economic Associates. The study conclusions are that by retaining high technology programs such as space and defense hardware as opposed to other low technology alternatives, there would be increased Federal tax revenues, higher employment levels and larger GNP.

The yearly (1978 - 1988) R&D costs, impact on GNP, employment and Federal tax revenues are shown in Table 4. The employment data were based on computations shown in the FY 1977 President's Budget and are explained by footnote in Table 4.

Table 5 shows by year, 1978 to 2000, the Federal tax revenues received each year that are related to R&D and production. The amounts related to production have been converted into discounted present value and statistically

applied to each of the R&D investment years.

Figure 1 is a graphical summary of the R&D costs and the related benefits derived by the government during both the R&D and production phases.

Also attached are opinions of the Council of Economic Advisors to the President and industry on the timing of government investment of R&D funds.

TABLE 1
NATIONAL PROBLEMS

- Unemployment

- U.S. Unemployment Rate in December 1975 was Highest Among Large Industrial Countries:

- U.S. Unemployment Rate	8.5 Percent
- U.S. Unemployed People	7.7 Million
- Average Number Receiving Unemployment Compensation	5.2 Million
- Unemployment Compensation Paid in 1975	\$18.4 Billion
- Additional New Jobs Needed Every Year Through 1980	1.5 Million
- Economic Assumption By The President For 1981 Is An Unemployment Rate of	4.9 Percent

- U.S. Trade Balance

- U.S. must continue to advance the Nation's aeronautical technology to enable private industry to maintain a strong U.S. competitive position in the international marketplace.
 - If U.S. does not develop and produce a new technology supersonic transport, U.S. will import to meet its requirements.
 - There is a \$32 billion 1975 constant dollars trade balance swing at issue.

TABLE 2
NEW TECHNOLOGY SUPERSONIC TRANSPORT PROGRAM (SST)
ECONOMIC BENEFITS TO THE NATIONAL ECONOMY
(1975 Constant Dollars)

<u>Actions</u>	<u>Year</u>
● Technology Development	1978 - 82
● Concurrent Engine and Airframe Development	1983 - 88
● Start Production	1989
● Total Shipments of 309 SSTs by	2000
<u>Development Costs</u> *	
● Technology Development	\$1 Billion
● Engine and Air Frame Development	<u>\$4-6 Billion</u>
Total Development Costs	\$5-7 Billion
<u>Economic Benefits</u>	
Adds Man Years of Employment	2.5 Million
Adds Jobs at Peak:	
During Development	100 Thousand
During Production	165 Thousand
Adds to GNP	\$80.1 Billion
Adds to Federal Taxes:	
During Development	\$ 3.5 Billion
During Production (present value \$5.0B)	\$12.5 Billion
Adds to U.S. Trade Balance	\$16.0 Billion

* Development costs range between \$5-7 billion. Government Share not yet determined. Worst case is for government to fully finance at the \$7.0 billion level. Return on government investment during development and production phases is \$16.0 billion in 1975 constant dollars and \$8.5 billion in present value dollars.

TABLE 3
COMPARATIVE INVESTMENTS

Using the large scale macroeconomic model of Chase Econometric Associates to evaluate the effects of three alternative spending mixes in a fixed total budget for the Federal Government in Fiscal Years 1973 and 1974. Spending adjustment in all alternatives was \$3.7 billion.

Alternatives

1. Holding the line on high technology expenditures, such as space programs and defense hardware.
2. Reducing grants in aid to the States.
3. Reducing Federal civil employment (5 percent)

Findings

Alternatives

	<u>2</u>	<u>3</u>
Federal deficit reduced (increased tax receipts)	\$1.5 B	\$1.2 B
GNP higher	8.8 B	6.0 B
Fewer people unemployed	130,000 people	

Conclusion

Retain the high technology programs. Results in smaller Federal deficits, higher employment levels and larger gross National product than the alternative in which technology is constrained.

Source: Understanding the Impact of Aerospace Programs on the National Economy, Bernard N. Kronberg, Chief Economists, Government Affairs, B-1 Division, Rockwell International, March 14, 1975 (Case Study C).

TABLE 4
FORECAST OF NEW TECHNOLOGY SST
DEVELOPMENT COSTS AND ECONOMIC BENEFITS
1978 - 1988
(1975 Constant Dollars in Millions)

Year	R&D Costs	Impact on GNP ^{1/}	Personnel ^{2/} Compensation	Aircraft ^{3/} Industry Employment	Total ^{4/} Employment	Fed ^{5/} Taxes
1978	\$ 40	\$ 100	\$ 30	1,320	3,960	20
1979	240	600	180	7,924	23,772	120
1980	240	600	180	7,924	23,772	120
1981	240	600	180	7,924	23,772	120
1982	240	600	180	7,924	23,772	120
1983	1,000	2,500	750	33,017	99,051	500
1984	1,000	2,500	750	33,017	99,051	500
1985	1,000	2,500	750	33,017	99,051	500
1986	1,000	2,500	750	33,017	99,051	500
1987	1,000	2,500	750	33,017	99,051	500
1988	1,000	2,500	750	33,017	99,051	500
Total	\$7,000	\$17,500	\$5,250	231,118	693,354	\$3,500

^{1/} GNP multiplier of 2.5 used.

^{2/} R&D is labor intensive. For this study it is assumed that 75 percent of the total R&D costs are for personnel compensation (see NASA budget for Research and Program Management, The Budget of the U.S. Government, FY 1977, p. 662)

^{3/} Average annual pay is the computed pay per person in the FY 1975 column of the FY 1977 NASA budget, for Research and Program Management in the above reference (\$22,715).

^{4/} Multiplier of 3 used.

^{5/} Paid by corporations and individuals. Approximately 20 percent of GNP.

TABLE 5
FORECAST OF NEW TECHNOLOGY SST
ADDED FEDERAL TAX REVENUES
1975 CONSTANT DOLLARS AND PRESENT VALUE
(Millions of Dollars)

<u>R&D INVESTMENT</u>		<u>A D D E D F E D E R A L T A X E S</u>					
		<u>R & D Phase</u>		<u>Production Phase</u>			
Year	Amount	1975 Constant Dollars	Present Value	1975 Constant Dollars	Present Value	1975 Constant Dollars	Present Value
1978	\$ 40	\$ 20	\$ 20	\$ 71	\$ 28	\$ 91	\$ 48
1979	240	120	120	429	171	549	291
1980	240	120	120	429	171	549	291
1981	240	120	120	429	171	549	291
1982	240	120	120	429	171	549	291
1983	1,000	500	500	1,787	712	2,287	1,212
1984	1,000	500	500	1,788	712	2,288	1,212
1985	1,000	500	500	1,788	712	2,288	1,212
1986	1,000	500	500	1,788	713	2,288	1,213
1987	1,000	500	500	1,788	713	2,288	1,213
1988	1,600	500	500	1,788	713	2,288	1,213
Total	\$7,000	\$3,500	\$3,500	\$12,514	\$4,987	\$16,014	\$8,487

<u>Production Year</u>	<u>Federal Taxes</u>	
1989	\$ 810	\$ 530
1990	891	530
1991	1,053	569
1992	1,053	517
1993	1,053	470
1994	1,053	428
1995	1,093	403
1996	1,093	367
1997	1,093	334
1998	1,094	303
1999	1,094	276
2000	1,134	260
Total	\$12,514	\$4,987

TIMING OF GOVERNMENT INVESTMENT IN R&D

Question - When should Federal government R&D funds be invested to encourage the earliest participation by the aeronautical industry in the R&D phase.

Answer- The Council of Economic Advisors to the President and industry (Boeing) both favor Government emphasis on technology development. (see below).

Council of Economic Advisors

Economic Report of the President, 1972 p. 126

"...Government has an appropriate role in R&D even when its results will not be incorporated in Government purchases, because private firms would underinvest in R&D for goods normally purchased by the private sector. Although an investment in R&D may produce benefits exceeding its costs from the viewpoint of society as a whole, a firm considering the investment may not be able to translate enough of these benefits into profits on its own products to justify the investment.

... One way to encourage more spending in R&D for private goods is, of course, by direct funding. When this approach is followed, it is sensible for Government's share of total expenditures to be greatest for basic research and to decline at subsequent stages."

Industry

Mr. J. E. Steiner, Boeing Company, in testimony before the Subcommittee on Aviation and Transportation R&D, May 11, 1976 presented a manufacturer's viewpoint on the "Future of Aviation, National Transportation System" said:

"The total need for development toward better commercial airplanes is vast. The fact that we have done relatively little for some years has placed us in a position where we, as a Nation, have no significant advantage in technology over foreign competitors. Regaining our former technological lead may, in fact, be impossible ... as someone once said 'we must simply run faster'. Running faster requires government sponsored technology development in conjunction with industries capability to integrate the results of basic research into viable economic products..."

SELECTED FEDERAL PROGRAMS
WHICH PROVIDE SUBSTANTIAL
ASSISTANCE TO THE
RAILROAD TRANSPORTATION INDUSTRY

Prepared by:
Operations Research, Inc.
July 28, 1976

INTRODUCTION AND SUMMARY

INTRODUCTION

This report covers four selected Federal programs which provide substantial financial assistance to the railroad transportation industry. The selected programs are:

- I. Washington, D. C. Metro System
- II. Conrail
- III. Metropolitan Scale Application of Automated Guideway Transit (AGT)
- IV. AMTRAK

Federal financial assistance for Conrail and AMTRAK is authorized by the Regional Rail Reorganization Act of 1973, the AMTRAK Improvement Act of 1975 and the Railroad Revitalization and Regulatory Act of 1976. Federal assistance for the other transportation programs is authorized under the Urban Mass Transportation Act of 1964 as amended.

Current costs of entire rail rapid transit systems are in the range of \$20-50 million per mile for capacities of about 30,000 passengers per hour per

direction. Underground lines cost as much as \$100 million per mile.

SUMMARY

The Washington, D. C. Metro system started operations on March 27, 1976 with 4.6 miles of completed track and 5 stations. The total cost for 100 miles of track and 87 stations is estimated to be between \$5.0 and \$6.5 billion. The completion date of 1982 is uncertain. The Mitre Corporation in a 1975 report indicates that the projected operating revenues won't even cover the interest charges that would normally be associated with such an investment. At the peak of construction there were 9,300 direct jobs and by using a multiplier of three, resulted in nationwide jobs for about 28,000 persons (including consumers and services).

The Conrail systems, aided by a \$6.4 billion Federal program is intended to keep the railroad industry in private hands and save it from further degredation. It is estimated that it will take at least eight years before Conrail will start to show a profit. It will operate 15,000 route miles and continue employment of 90,000 of the 97,839 employees of the bankrupt Northeast railroads.

The Metropolitan Scale Applications of Automated Guided Transit (AGT) requires a capital investment of \$7.8 billion of which the Federal government will finance up to 80 percent (\$6.2 billion). The AGT covers 380 miles of dual guideway in four metropolitan areas in the United States.

Congress recently approved a \$1.6 billion rail improvement program for AMTRAK to provide high-speed railroad passenger service in the densely populated Northeast Corridor of the U. S. AMTRAK commenced operations in 1971, reported deficits of \$150 million in 1973 and more than \$320 million in 1975. An operating deficit in 1980 is estimated as \$400 million. "For each

of almost 19 million passengers," the New York Times in 1974 states that,
"taxpayers will pay more than \$12 for his ride."

I. WASHINGTON, D. C. METRO SYSTEM

Metro is the largest rail rapid system ever built under one plan at one time. Congress ordered a physical start to the system in 1960. The U. S. Government made a grant of \$1.1 billion (\$1.6 billion in 1975 constant dollars) in 1969 at which time the ground was broken. Some pertinent data regarding the Metro system follows:

- Cost of total system, \$5.0 to \$6.5 billion
- 100 miles--87 station network, 53 stations underground
- Half of stations under construction or completed
 - 4.6 miles--5 stations completed March 27, 1976
 - 40.7 miles--37 stations under construction
- 556 cars will be in service when system is completed
 - Rohr cars are 75 feet long
 - Carry 81 passengers seated and another 94 standees
 - Run at 75 mph, averaging 35 mph including stops
- In 1972 the government guaranteed revenue bonds sold by the

transit authority. Other national funds come from unused federal highway grant programs for the region.

- At the peak of construction activity:
 - Construction contractors employed 7,300 laborers and skilled craftsmen
 - Another 2,000 persons are directly employed in Washington and elsewhere in the U. S. in planning, engineering, and technical aspects relating to construction or operation of the system.
- Current fare is 55 cents during rush hour and 40 cents during non-rush hours. Handicapped and elderly people with special identification cards travel for half fare during nonrush hours. In the second and subsequent phases, fares will be based on distance travelled.
- Projected operating revenues won't even cover the interest charges that would normally be associated with such an investment.

Sources: Transportation Research News, May-June 1976
Transportation in the U. S., An Appraisal, The Mitre Corp.,
January 1975. p. 35
Washington Post, July 22, 1976.

II. CONRAIL

A \$6.4 billion federal program is designed to reorganize the Penn Central and other bankrupt carriers, provide funds for still other needy railroads, and upgrade Northeast Corridor service. "This is our last chance at developing a comprehensive program to keep the railroad industry in private hands, to save it from further degredation and eventual nationalization," says Representative Fred B. Rooney (D-Pa.), chairman of the House subcommittee dealing with railroad problems. The Consolidated Railroad Corporation (Conrail) has taken over the operations and will operate 15,000 route miles, with 90,000 personnel, 159,000 freight cars and 4,162 locomotives.

John Ingraham, First National City Bank vice president, estimates that Conrail would have a profit of \$55 million in its eighth year. The U. S. Railway Association (USRA) also predicts that Conrail would be reasonably profitable in its eighth year, but assumes that this will depend on federal loan guarantees.

Sources: Business Week, June 2, 1975, August 11, 1975, November 24, 1975, and April 19, 1976.

III. METROPOLITAN SCALE APPLICATION OF AUTOMATIC GUIDEWAY TRANSIT (AGT)

Four metropolitan networks have made serious studies and are considering the purchase of AGT for their locales. These would require a capital investment of \$7.8 billion dollars. If approved, the Federal Government might be called on to finance 80 percent of the costs (\$6.2 billion).

The metropolitan networks are:

- Regional Transportation District, Denver, Colorado.
 - 100 route miles of double guideway
 - 67 stations
 - 800 12-passenger vehicles
 - Capital cost, \$2.1 billion
- Twin Cities Area, St. Paul/Minneapolis
 - 81 miles of dual guideway
 - 114 stations
 - Capital cost \$1.7 billion

- San Diego Region, California
 - 59 miles of dual guideway
 - 57 stations
 - vehicle fleet containing 17,500 seats
 - Capital cost, \$1.6 billion
- Santa Clara County, San Jose, California
 - 140 miles of dual guideway
 - 140 stations
 - Capital costs, \$2.35 billion

Source: Panel Reports on Automated Guideway Transit In Support of an Assessment of PRT and Other New Systems. Prepared for the Office of Technology Assessment, U. S. Congress, May 1975.

IV. AMTRAK

Congress recently approved a \$1.6 billion Northeast rail improvement program. This is in addition to the \$6.4 billion Federal program designed to reorganize the Penn Central and other bankrupt carriers.

AMTRAK commenced operations in 1971. The Secretary of Transportation reported a 1973 deficit of \$150 million compared with total revenues of \$177 million, 46 percent of which was in a Federal subsidy. Some pertinent data regarding AMTRAK follows.

- 1975 selected statistical data:
 - 25,000 mile system
 - Will lose more than \$320 million
 - Costs per passenger mile are 15.4 cents
 - Revenues per passenger mile are 6.7 cents
 - If every Amtrak seat were filled, the system would still lose over \$75 million in this year

● Other selected data:

- AMTRAK's Floridian--Chicago to St. Petersburg, Florida.
Roomette costs passenger \$120, AMTRAK subsidizes his trip to the tune of \$264. The Government could save money by giving each of these customers first-class airfare, plus \$100 to spend on the beach.
- Even with twice as many riders AMTRAK projects operating deficits of \$400 million a year in 1980.
- The New York Times, dated December 1974, stated, "for each of the almost 19 million passengers the system will carry, taxpayers will pay more than \$12 for his ride."

Sources: Business Week, April 19, 1976.
Fortes, December 1975.
Transportation in the U. S., An Appraisal, The Mitre Corporation,
January, 1975.